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SPECIAL FEATURES

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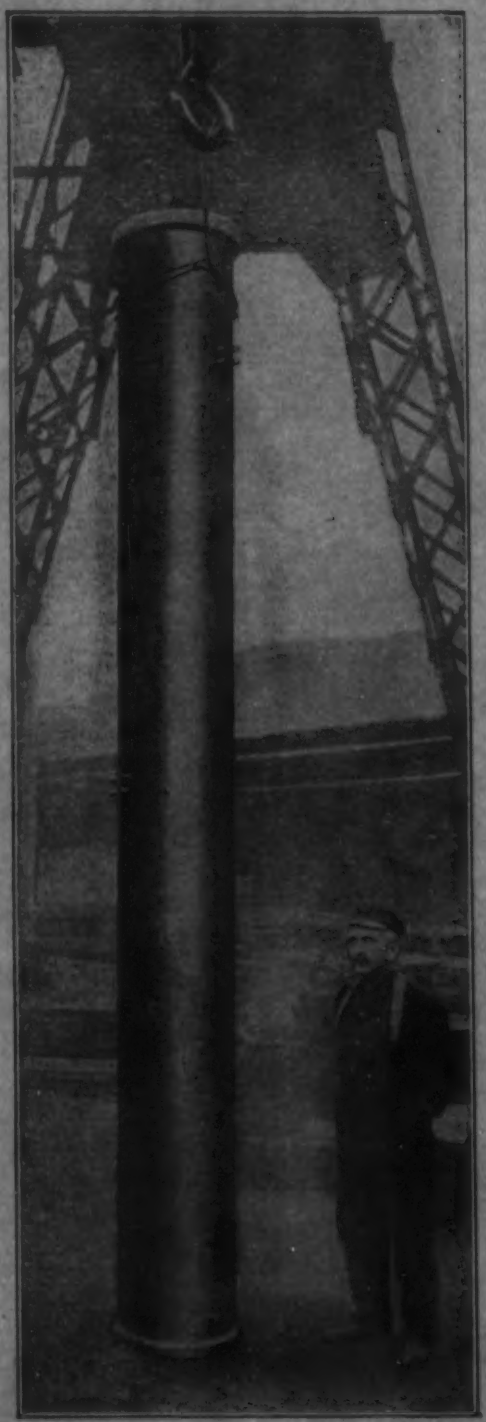

Calite tube 13'6" long, 16" dia., 1" wall.
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After years of research the engineers of the General Electric Company have developed and patented this high temperature alloy CALITE.

Here are some of its features: 14% lighter than the nickel-chromium alloys on the market today.

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Resists heat to a greater extent than any other heat resisting alloy casting obtainable at the present time.

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TRANSACTIONS

of the

American Society for Steel Treating

Vol. II Cleveland, April 1922 No. 7

PROPOSES STANDARDS FOR CARBON AND ALLOY STEEL COMPOSITIONS

ATTENTION of members of the Society is directed to the communication and report of the Standards Committee on page 557 of this issue of TRANSACTIONS. After considerable time and effort this committee has prepared and submitted to the membership a proposed set of standards for the chemical compositions of both carbon and alloy steels. In a number of cases, the same standards as sanctioned by the Society for Automotive engineers are recommended, but in other cases some modifications have been found desirable. This committee now solicits criticisms and suggestions in order that any necessary changes may be made in sufficient time that definite recommendations for a set of standards may be made at the Detroit Convention, Oct. 2 to 7. All letters proposing changes must be in the hands of the committee by May 26 when it will hold its next meeting.

If the Society is to expect the Standards Committee to accomplish any notable work such as it has started at the present time, the chapters and membership must give it the greatest co-operation. A responsibility rests upon chapter officers to see that the proposed standard analyses are brought to the attention of the chapter at the next meeting where they may be discussed openly. Following this, a committee should be appointed to consider the proposed standards and to report to the National Office whether they are considered favorable or unfavorable. Individual members should send their suggestions in direct. Within recent years the matter of standards and standardization has received wide attention, and it is only in line with the general progress that this Society should adopt a suitable set of standards.

PROGRAM ANNOUNCED FOR PITTSBURGH SECTIONAL MEETING

W. J. MERTEN, chairman of the Papers and Meetings Committee of the Pittsburgh Chapter has issued an announcement giving the program for the Spring Meeting of the National Society at Pittsburgh, May 25 and 26. This committee as well as the various other committees on arrangements have accomplished excellent results and have everything in shape for a successful meeting.

Since the New York Meeting was such a decided success and attracted so many out-of-town guests, the Pittsburgh Chapter contemplates that the program and entertainment features as well as the exceptional opportunity afforded for plant visitation will combine in producing a large attendance from outside chapters.

The papers to be presented at the Pittsburgh meeting will be pub-

lished in the May issue of TRANSACTIONS which it is hoped will be in the hands of all members not later than the first of May. Discussion is invited on all the papers and it is hoped that many members will take the opportunity to comment upon the papers to be presented. The program is as follows:

PROGRAM FOR THE SPRING SECTIONAL MEETING AT PITTSBURGH, MAY 25 TO 27

Thursday, May 25

11 a. m. to 1 p. m.—Auditorium, Bureau of Mines.

Informal gathering and registration of out-of-town members and guests. In charge of W. H. Eisenman, National Secretary, assisted by Messrs. Horne, Phillips, and Cook.

1:30 p. m. to 4:30 p. m.—Auditorium, Bureau of Mines.

Address of welcome, by Chairman of Pittsburgh Chapter.
Response by National President, F. P. Gilligan.
Technical Session presided over by Past Chairman of Pittsburgh Chapter.
Papers by:

Professor McIntosh, Carnegie Institute of Technology, "Fiber in Steel and Iron".
W. B. Crowe, metallurgist, Carnegie Steel Company, "Mass Influence on Heat Treating".

7:00 p. m.—University Club—Banquet.

Addresses and music relayed over KDKA, Westinghouse Radiophone station.
Toastmaster—G. H. Neilson, president, Braeburn Steel Co. and past president, Western Pennsylvania Engineers Society.
Speakers—Doctor Bowman, chancellor, University of Pittsburgh; Dr. J. A. Mathews, president, Crucible Steel Co. of America; Prof. F. Crabtree, chairman, American Institute of Mining and Metallurgical Engineers, Pittsburgh Division; and vice chairman, Western Pennsylvania Engineers Society. "History of Metallography and Heat Treatment of Iron and Steel".
Followed by impromptu speeches by guests representing prominent local industries.
Music by Greater Pittsburgh Quartet.

Friday, May 26

9:00 a. m. to 12:00 m.

Assembly at Schenley Hotel to visit steel mills and manufacturing plants.

1:30 p. m. to 4:30 p. m.—Auditorium, Bureau of Mines.

Technical Session—Presided over by Chairman of visiting section.
Papers by:

Mr. Cox, R. D. Nuttall Co., "Abrasive Qualities of Carbon and Alloy Steels".
J. A. Succop, Heppenstall Forge & Knife Co., "The Importance of Properly Heated and Cooling Steel".
Mr. Smith, Union Spring & Manufacturing Co., New Kensington, Pa., "Manufacture of Springs".
Mr. Grossman, Electric Alloy Steel Co., Youngstown, O., "Shrinkage of High Speed Steels".

7:30 p. m. to 11:00 p. m.—Auditorium and Cafeteria, Bureau of Mines.

Open-Hearth Furnace Film—American Rolling Mill Company.
Smoker, in charge of Entertainment Committee.

Saturday, May 27

10.00 a. m.—Auditorium, Bureau of Mines.

Directors meeting.

8:00 p. m.

Carnegie Institute of Technology, School of Dramatic Arts. Little Theater play by School of Dramatic Arts.

HOTEL RESERVATIONS FOR DETROIT CONVENTION

Statler Hotel, Convention Headquarters

DETROIT has promised to provide all of our members and guests with excellent accommodations as far as hotels are concerned. Through the efforts of D. J. Crowley, 832 Dime Bank Building, Detroit, Chairman of the Hotel Committee, a list of hotels is given below with their rates for single and double rooms as well as the number of reservations each hotel will accept. The Statler Hotel will be the official headquarters. All persons in attendance at Detroit will make their own hotel reservation direct with the managers and it is advisable that the members take the following precaution: When making reservations, state that you are attending the International Steel Exposition and Convention of the American Society for Steel Treating, give the date of arrival, kind of room desired and the price you wish to pay. Request the hotel manager to answer your letter repeating the reservation, then take the letter with you to Detroit and present it when you register. This precaution taken now may avoid serious difficulty during the rush of the Convention. It is recommended that reservations be made immediately.

The list of hotels follow:

Lincoln Hotel

Rate Without Bath
Single $1.25, $1.50, $1.75, $2.00
Double $2.50, $3.00 (2 men)

Rate With Bath
Single 6 showers and tubs on each floor
Double no private baths

Will accommodate 75

Remarks: Large lobby. Good cafeteria.

Hotel Fort Shelby

Rate Without Bath
Single $2.00
Double $3.00

Rate With Bath
Single $3.00, $3.50, $4.00, $5.00
Double $5.00, $6.00, $7.00

Will accommodate 50 to 100

Cadillac Hotel

Rate Without Bath
Single 2.00, $2.50
Double $3.00, $3.50, $4.00

Rate With Bath
Single $2.50, $3.00, $3.50, $4.00
Double $4.00, $5.00, $6.00, $7.00

Will accommodate 500

Charlevoix Hotel

Rate With Bath
Single $3.00, $3.50, $4.00
Double $5.00, $6.00

Two-Room Suites.....$7.00
Three-Room Suites $8.25
Four-Room Suites $9.00

Number of persons with notice—100

Hotel Wolverine

Rate With Bath
Single $2.50, $3.00, $3.50, $4.00, $4.50, $5.00, $6.00
Double $4.50, $5.00, $5.50, $6.00, $6.50, $7.00, $8.00

Will accommodate 300

Hotel Norton

Rate Without Bath
Single $2.00 to $2.25
Double $4.00

Rate With Bath
Single $2.50 to $3.00
Double $4.50 to $5.50

Will accommodate 100

Hotel Normandie

Rate Without Bath	Rate With Bath
Single $1.50 to $2.00	Single $2.50 to $3.00
Double $2.50 to $3.00	Double $3.50 to $4.00

Will accommodate 100

Madison-Lenox

Rate Without Bath	Rate With Bath
Single $2.00	Single $2.50, $3.00
Double $3.00	Double $3.50, $4.00

Will accommodate 100 or more

Library Park Hotel

Rate Without Bath	Rate With Bath
Single $1.25 to $2.00	Single $3.00
Double $2.00 to $3.00	Double $4.00

Will accommodate 50

Hotel Stevenson

Rate With Bath
Single $2.50
Double $3.50
Will accommodate 50

Hotel Statler

Rate With Shower	Rate With Bath
Single $3.00 to $3.50	Single $4.00 to $ 8.00
Double $5.00 to $5.50	Double $6.00 to $10.00

Will accommodate—400 rooms to take care of 600 to 800 people

Hotel Tuller

Rate With Bath
Single $2.50
Double $4.50
Will accommodate 300

Hotel Griswold

Rate Without Bath	Rate With Bath
Single $2.00	Single $2.50, $3.00, $3.50
Double $3.00	Double $4.00, $5.00, $6.00

Will accommodate 125

Hotel Addison

Rate Without Bath	Rate With Bath
Single $1.50	Single $2.50
Double $3.00	Double $4.00

Will accommodate 250

ARRANGES TECHNOLOGIC PAPERS FOR REFERENCE

THE following announcement recently made by the Bureau of Standards, Washington, suggesting a standard method for collecting and binding technologic papers issued by the bureau periodically probably will be of interest to members of the American Society for Steel Treating. The announcement is as follows:

"The need for citation to the Technologic Papers of the Bureau of Standards has brought requests that they be grouped into volumes, each volume being consecutively paged. Most libraries do not usually index pamphlets, and as these Technologic Papers are classed as pamphlets, their reference value is lost. To combine the advantages of the separate reprint system and the volume plan will be so helpful that beginning with Technologic Paper No. 203 the paging will be consecutive in the series until 750 pages are reached. This will permit gathering together the Technologic Papers into volumes wherever desired.

"Since 202 papers are already issued, a suggested grouping for these

also is published herein to aid those who may have complete sets unbound. The volume is uniform in style and size with that of the Scientific Papers of the Bureau of Standards. Since so few copies are available for free distribution, it is no longer possible to complete all the sets from the beginning. The Superintendent of Documents maintains a sales stock which will help to complete back sets, and he reprints any publication for which there is sufficient demand.

"The suggested grouping of Technologic Papers into volumes need not be followed by libraries which classify the papers on the shelves by subjects, but the suggested grouping will be convenient for those libraries which maintain the series in consecutive order as sent out. The grouping suggested for binding in such cases is as follows:

Vol. No.	Begins with—	Vol. No.	Begins with—	Vol. No.	Begins with—	Vol. No.	Begins with —
1.....	T 1	5.....	T43	9.....	T 85	13.....	T143
2.....	T12	6.....	T54	10.....	T101	14.....	T170
3.....	T20	7.....	T61	11.....	T109	15.....	T184
4.....	T32	8.....	T74	12.....	T121	16.....	T203

"Cited references to earlier Technologic Papers, issued prior to No. 203 which begins volume 16, should be to the separate papers, that is, "Bureau of Standards Technologic Papers, No. 170, p. 92, 1921."

"A title page and index, issued separately, will be transmitted with the last Technologic Paper of each volume to those libraries or subscribers who receive the complete series.

"Subscriptions can be placed for the series of Technologic Papers by sending written orders addressed "Superintendent of Documents, Government Printing Office, Washington, D. C.," and inclosing $1.25 to cover a sufficient number of the papers to make one volume ($2.50 is required if the publications are to be mailed to foreign countries). Separate numbers of the Technologic Papers may be purchased at nominal cost by sending to the same address. Do not address orders with money to the Bureau of Standards or the Department of Commerce.

"Circular 24 contains a descriptive list of all Bureau of Standards publications issued since the establishment of the Bureau. An extended abstract shows clearly the nature of the subject matter and gives in many cases a brief summary of the result. This list will be distributed to applicants free of charge."

PREDICTS FUTURE FOR MAGNETIC TESTING

THE following editorial entitled "An Advance in Magnetic Testing" appeared in the March 9 issue of the *Iron Age* and is of timely interest. It was occasioned by the paper "The Magnetic Testing of Small Case Hardened Chain" which was presented by A. V. deForest at the New York Sectional meeting of the Society held on March 3. The editorial read as follows:

"Magnetic testing has now been applied for determining the efficacy of case hardening. More than that, it has been applied in a practical way that suggests broad possibilities. Announcement of the development was made at the meeting last week to discuss steel treating problems and covered the perfection of an apparatus used for testing the case hardness of small chain. Briefly, by empirically determining the maximum and mini-

mum depths of case in chain corresponding to poor results, an approximate standard is established by which it is possible to determine magnetically the depth of case which will give the longest life for definite conditions. This has already afforded a test basis which is being applied commercially.

"This principle may, in the not distant future, be applied to other properties of steel. The designers of the apparatus are making just such predictions and assert that it will be possible to correlate the tensile strength or ductility as easily by magnetic tests as the case hardness of steel. All that appears necessary is the determination of maximum and minimum limits within which the material will be satisfactory and use these for the fixing of a standard. There are those who do not appreciate that this is really the principle on which most specifications are now based. New apparatus will not be needed, it is claimed. The application of the magnetic testing idea to case hardened chain is after all merely a step in the development of nondestructive testing for which there has long been a demand."

A HISTORIC DESCRIPTION OF DAMASCUS SWORD MAKING

IN SYRIAC characters, in the ruins of ancient Tyre was found the method of making perfect Damascus sword blades. Translated the procedure was as follows:

"Let the high dignitary furnish an Ethiope of fair frame, and let him be bound down, shoulders upwards upon the block of the God Bal-hal, his arms fastened underneath with thongs; a strap of goatskin over his back, and wound twice around the block; his feet close together lashed to a dowel of wood, and his head and neck projecting over and beyond the block - - - Then let the master workman, having cold hammered the blade to a smooth and thin edge, thrust it into the fire of the cedarwood coals, in and out, the while reciting the prayer to the God Bal-hal, until the steel be of the color of the rising sun when he comes up over the desert toward the East and then with a quick motion pass the same from the heel thereof to the point, six times through the most fleshy part of the slave's back and thighs, when it shall have become the color of the purple of the king. Then if with one swing and one stroke of the right arm of the master workman it severs the head of the slave from his body, and display not nick nor crack along the edge, and the blade may be bent round about the body of a man and break not, it shall be accepted as a perfect weapon, sacred to the service of the God Bal-hal, and the owner thereof may thrust it into a scabbard of asses' skin, brazen with brass, and hung to a girdle of camels' wool dyed in royal purple."

STANDARDS COMMITTEE REPORTS ITS PROGRESS

BELOW will be found a communication from the Standards Committee of the American Society for Steel Treating which accompanied the proposed standards on the composition of steel. In preparing these standards the committee has done a considerable amount of work but has reached the point where criticisms and suggestions are desired. Another meeting will be held May 26 at which time all communications will be considered. The committee's letter is as follows:

"Subject: Composition of Steel—Standards.

"At a meeting of the Standards Committee in New York, March 2, 1922, a report was submitted by a subcommittee giving a proposed A. S. S. T. Analysis by the numbering system.

"The first list gives the key to the numbering system which it will be found corresponds to the S. A. E. plan but slightly extended to meet the more general needs of the A. S. S. T. Following that are given lists of steels that we wish to establish as standards, covering the plain carbon and alloy steels.

"The Committee voted that I, as chairman of the Committee, request the following co-operation:

"Send copies to each chapter of A. S. S. T. and publish same in the TRANSACTIONS with a notation that:

1. There is a growing national demand for a numbering system for chemical analysis of steels.
2. There is a national need for standardizing chemical analysis of steels.
3. The numbering system of the S. A. E. has become well established.
4. The national standards committee of the A. S. S. T. has worked out the attached tentative list of chemical analysis of steel which they propose to offer to the Society at the next annual convention, to be held at Detroit, Oct. 2 to 7, as standards.

"It is desired that each and all chapters take up this subject as a chapter matter and let the Standards Committee have their comments, criticisms or additional analyses that the several chapters may desire to offer.

"Individual members of the A. S. S. T. are requested to study the proposed standards and send in their comments and criticisms.

"We desire to have another meeting of the Standards Committee in Pittsburgh on or about May 26, 1922, and would appreciate replies before that meeting.

"The earnest co-operation of all members is desired by the Standards Committee and we shall expect full criticisms from those who have something better to propose.

"This we think is part of the foundation of the Standards Committee's work in building up the National Society.

Yours truly,
STANDARDS COMMITTEE,
ROBERT BIRD,
J. H. G. WILLIAMS,
T. D. LYNCH, Chrm.

"Send all comments and criticisms to the National office, 4600 Prospect Avenue, Cleveland, O."

PROPOSED A. S. S. T. STANDARDS

Key to Numbering System

"GRADE" Designated by the 1st number

- 10-00 Carbon
- 20-00 Nickel
- 30-00 Nickel Chromium
- 40-00 Molybdenum
- 50-00 Chromium
- 60-00 Chrome Vanadium
- 70-00 Tungsten
- 90-00 Silico Manganese

"TYPE" Designated by the 2nd number

- 00-00 General for Carbon Steels
  - 11-00 High Phosphorus and Sulphur
  - 12-00 Steel Casting
- 01-00 Indicates content of Main Alloy
- 02-00 Indicates content of Main Alloy
- 03-00 Indicates content of Main Alloy
- 04-00 Indicates content of Main Alloy
- 05-00 Indicates content of Main Alloy
- 06-00 High Manganese
- 08-00 Close Limits—Physical Requirements

"CARBON CONTENT" Designated by last two numbers

- 00-05 Average .05 Carbon
- 00-10 Average .10 Carbon
- Etc.

Illustrations

10-15	10-20	Carbon Simple Carbon	Case Hardening
10-36	30-40	Carbon Simple Carbon	Forging Steel
11-12	08-16	Carbon High Phosphorus and Sulphur	Free Cutting
25-35	30-40	Carbon 3.5 per cent Nickel	
32-30	25-35	Carbon Intermediate Nickel Chrome	
33-25	20-30	Carbon Full Nickel Chrome	

Carbon Steels

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Silicon	
10-00	-25	-50	05	-06		
10-10	05-15	30-60	045	05		SAE
10-15	10-20	30-60	045	05		SAE
10-20	15-25	30-60	045	05		SAE
10-21	10-30	20-80	05	06		
10-25	20-30	50-80	045	05		SAE
10-30	25-35	50-80	045	05		SAE
10-35	30-40	50-80	045	05		SAE
10-36	30-40	40-60	045	05		
10-40	35-45	50-80	045	05		SAE
10-41	35-45	40-60	045	05		
10-45	40-50	50-80	045	05		SAE
10-46	40-50	40-60	045	05		SAE
10-50	45-55	50-80	045	05		SAE
10-51	45-55	40-60	045	05		
10-55	50-60	40-60	045	05		
10-60	55-65	60-80	045	045		
10-65	60-70	50-70	04	045		
10-70	65-75	30-60	04	045		
10-75	70-80	20-50	04	045		
10-80	75-85	20-50	04	045		
10-85	80-90	20-50	04	045		
10-90	85-95	20-50	04	045		
10-94	90-1.00	20-50	04	045	15-25	
10-95	90-1.05	20-50	05	05		SAE
10-99	90-1.10	20-50	05	05		

High Phosphorus and Sulphur Steels

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Nickel	
11-12	08-16	60-80	09-13	075-.15		SAE
11-20	15-25	60-90	06	075-.15		SAE

Nickel Steels

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Nickel	
21-30	27-33	40-60	04	04	1.00/1.25	
23-12	18	30-60	04	045	3.25/3.75	SAE
23-15	10-20	30-60	04	045	3.25/3.75	SAE
23-20	15-25	50-80	04	045	3.25/3.75	SAE
23-30	25-35	50-80	04	045	3.25/3.75	SAE
23-35	30-40	50-80	04	045	3.25/3.75	SAE
23-40	35-45	50-80	04	045	3.25-3.75	SAE
23-45	40-50	50-80	04	045	3.25/3.75	SAE
23-50	45-55	50-80	04	045	3.25/3.75	SAE
25-12	17	30-60	04	045	4.50/5.25	SAE

Nickel Chrome—Mayariz

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Nickel	Chromium	
31-12	.18	30-60	.04	.04	1.00/1.50	45-75	
31-15	10-20	30-60	.04	.04	1.00/1.50	45-75	SAE
31-20	15-25	30-60	.04	.045	1.00/1.50	45-75	SAE
31-25	20-30	50-80	.04	.045	1.00/1.50	45-75	SAE
31-30	25-35	50-80	.04	.045	1.00/1.50	45-75	SAE
31-35	30-40	50-80	.04	.045	1.00/1.50	45-75	SAE
31-40	35-45	50-80	.04	.045	1.00/1.50	45-75	SAE
31-45	40-50	50-80	.04	.045	1.00/1.50	45-75	
31-50	45-55	50-80	.04	.045	1.00/1.50	45-75	

Nickel Chrome—Intermediate

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Nickel	Chromium	
32-12	17	30-60	.04	.04	1.50/2.00	90/1.25	
32-15	10-20	30-60	.04	.04	1.50/2.00	90/1.25	SAE
32-20	15-25	30-60	.04	.04	1.50/2.00	90/1.25	SAE
32-25	20-30	30-60	.04	0.45	1.50/2.00	90/1.25	
32-30	25-35	30-60	.04	.04	1.50/2.00	90/1.25	SAE
32-35	30-40	30-60	.04	.045	1.50/2.00	90/1.25	
32-40	35-45	30-60	.04	.04	1.50/2.00	90/1.25	SAE
32-45	40-50	30-60	.04	.04	1.50/2.00	90/1.25	SAE
32-50	45-55	30-60	.04	.04	1.50/2.00	90/1.25	SAE
32-55	50-60	30-60	.04	.045	1.50/2.00	90/1.25	SAE

Nickel Chrome—Full

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Nickel	Chromium	
33-10	15	30-60	.04	.04	3.25/3.75	1.25/1.75	
33-12	17	30-60	.04	.04	3.25/3.75	1.25/1.75	SAE
33-19	15-25	30-60	.04	.045	3.00/3.50	1.00/1.50	
33-25	20-30	30-60	.04	.04	3.25/3.75	1.25/1.75	SAE
33-29	25-35	30-60	.04	.045	3.00/3.50	1.00/1.50	
33-34	30-40	30-60	.04	.045	3.00/3.50	1.00/1.50	
33-35	30-40	30-60	.04	.04	3.25/3.75	1.25/1.75	SAE
33-39	35-45	30-60	.04	.045	3.00/3.50	1.00/1.50	
33-40	35-45	30-60	.04	.04	3.25/3.75	1.25/1.75	SAE

Nickel Chrome—"French"

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Nickel	Chromium	
34-12	18	30-60	.04	.04	2.75/3.25	60-95	
34-15	10-20	45-75	.04	.04	2.75/3.25	60-95	SAE
34-35	30-40	45-75	.04	.04	2.75/3.25	60-95	SAE
34-50	45-55	45-75	.04	.04	2.75-3.25	60-95	SAE

Chrome Steels

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Nickel	Chromium	
51-20	15-25	30-60	.04	.045		60-90	SAE
51-40	35-45	50-80	.04	.045		80/1.10	SAE
51-50	45-55	50-80	.04	.045		80/1.10	SAE
51-65	60-70	25-50	.04	.045		60-90	
52-100	95/1.10	20-50	.03	.03		1.20/1.50	SAE

Chrome Vanadium

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Chromium	
61-20	15-25	50-80	.04	.04	80/1.10	SAE
61-25	20-30	50-80	.04	.04	80/1.10	SAE
61-30	25-35	50-80	.04	.04	80/1.10	SAE
61-35	30-40	50-80	.04	.04	80/1.10	SAE
61-40	35-45	50-80	.04	.04	80/1.10	SAE
61-45	40-50	50-80	.04	.04	80/1.10	SAE
61-50	45-55	50-80	.04	.04	80/1.10	SAE
61-95	90/1.05	20-45	.03	.03	80/1.10	SAE

Silico Manganese Steel

Analysis No.	Carbon	Manganese	Phosphorus	Sulphur	Silicon	
92-50	45-55	60-90	.045	.045	1.80/2.20	SAE
92-60	55-65	60-90	.045	.045	1.80/2.20	SAE

STAINLESS STEELS AND THE MAKING OF CUTLERY

By R. G. Hall

COMMERCIAL utilization of the noncorrodible properties of steel containing about 13 per cent of chromium may be regarded as one of the outstanding events in the metallurgical world during the last decade. Unfortunately, steel, the most widely used metal, corrodes rather easily and great precautions have to be taken to protect it, especially in exposed positions. This is particularly noticeable in large engineering structures such as the great railway bridges where painting is going on practically continuously. The production of a type of steel possessing great resistance to corrosion obviously has a great future and one may safely say that as yet only the fringe of its possibilities has been touched.

Stainless steel, on account of its peculiar property of resisting oxidation and corrosion by the ordinary agents when properly hardened and finished was in great demand during the late war. Nearly all stainless supplies in England were appropriated by the minister of munitions, thus showing its importance during this stress period. The bulk of this material was used for exhaust valves in aero engines, on account of its strength and resistance to corrosion at high temperatures thus its use for cutlery was retarded.

The discovery of this steel was very unique because of the fact that two men working entirely independent of one another discovered the alloy at practically the same time. In 1911, Elwood Haynes, Kokomo, Ind., made experiments with alloys of iron and chromium with a view to determining the effects of chromium on the resistance of steel to chemical and atmospheric influences, also its effect on the hardness and cutting qualities of steel.

At about the same time or possibly a little later, Harry Brearley, a noted metallurgist of Sheffield, England, discovered that the introduction of approximately 13 per cent chromium to ordinary carbon steel, rendered it impervious to oxidation by air, water, or such acids that are usually met with in household use. The application of this steel to cutlery was made possible only after much experimenting and study by the various manufacturers of this particular line of goods.

The author has read a great mass of information compiled by several engineers as to the general characteristics of stainless steel for cutlery but he will not attempt to extract their points upon this particular steel for cutlery. Instead he will give the information as it has been worked out successfully at the fire and wheel. The writer has found great difficulty in studying the information as submitted by different authorities as there seems to be a great divergence of opinion as to practically all essential points, including the exact chemical specifications. A wide range of opinion exists as to the subsequent handling and heat treating of the alloy.

In enumerating these experiments, no attempt will be made to segregate them under separate headings but they will be given in abstract form. As to the analysis of the steel for cutlery, it is recommended that the carbon content be between 0.30 and 0.45 per cent and the chromium between 13 and 15 per cent. Doctor Hatfield recommends 13 per cent.

A paper presented at the New York Sectional Meeting. The author, R. G. Hall, is research engineer, R. Wallace & Sons Mfg. Co., Wallingford, Conn.

The Brearley patents call for chromium between 9 and 16 per cent while Elwood Haynes has covered in his patents up to 16 per cent. It is the opinion of the writer and others, however, that nothing is gained in stainless characteristics or corrosion by exceeding 15 per cent chromium. Phosphorus and sulphur should be below 0.03 per cent with silicon and manganese about 0.30 and 0.50 per cent respectively.

The steel generally used for cutlery is bought in round rods in convenient length to handle according to methods used in its manufacture. Some cutlery manufacturers work this steel from the bar, while others fabricate it to the desired lengths. The writer prefers the latter method because of its convenience and economy in scrap. Great care should be used in this method with reference to the tools used in fabrication because the cutlery troubles begin at this point. The steel always should be kept well annealed and if the tools are kept sharp, there should be no difficulty in cutting the material to the desired lengths. Dull tools at this point have a tendency to tear off the steel whereby small cracks are started in the end of some of the pieces and this generally leads to seamy portions in the blades. Steel manufacturers often are blamed for seamy stock when in reality the trouble has been due to dull tools. It might be stated here that in the early stages of this steel for cutlery, great difficulty was experienced at the mills in manufacturing this steel free from seams but today this trouble has been reduced to a minimum.

After the steel is cut into the desired lengths, it is taken to the drop forging room where it is forged into the desired shape. From here it passes on to the rolls where the blade is rolled out. Great care must be taken in these operations to maintain the heat at its proper forging temperature, especially at the roll, because at this point a part of the blade is nearly at its desired thickness while the remainder of the piece is still in its original round shape. The heat generally used at these stages of the manufacture range from 1650 to 1750 degrees Fahr.

The work must be kept as free as possible from oxidation because any scale rolled into the steel at this time may form a seat of corrosion even after the blade has been finished. When working with small thin sections, the alloy should never be allowed to cool on a damp cold floor on account of the air hardening qualities of this steel. Strains will be set up which later will develop into cracks, thus rendering the blade useless.

The next step in the manufacture is the annealing operation. The work is usually put into a receptacle and brought slowly up to about 1380 to 1400 degrees Fahr., generally in a muffle furnace, after which it is allowed to cool slowly. Following this operation the blades are blanked out into the desired shapes. Great care should be used at this point to see that the tools are kept sharp at all times, thus reducing the possibilities of cracks. These cracks caused by dull tools are not seen at this particular point and sometimes do not show up until considerable more labor has been expended.

The next step in the manufacture is the hardening operation, and this is one of the most difficult operations in the making of the whole knife. The hardening and tempering of stainless steel has much to do with its stainless characteristics, thus great care must be exercised. Stainless steel may be hardened in air, oil, or water, the quenching temperature really depending upon the method used. In the author's opinion, it should always be done in oil from a temperature ranging between 1650 to 1900

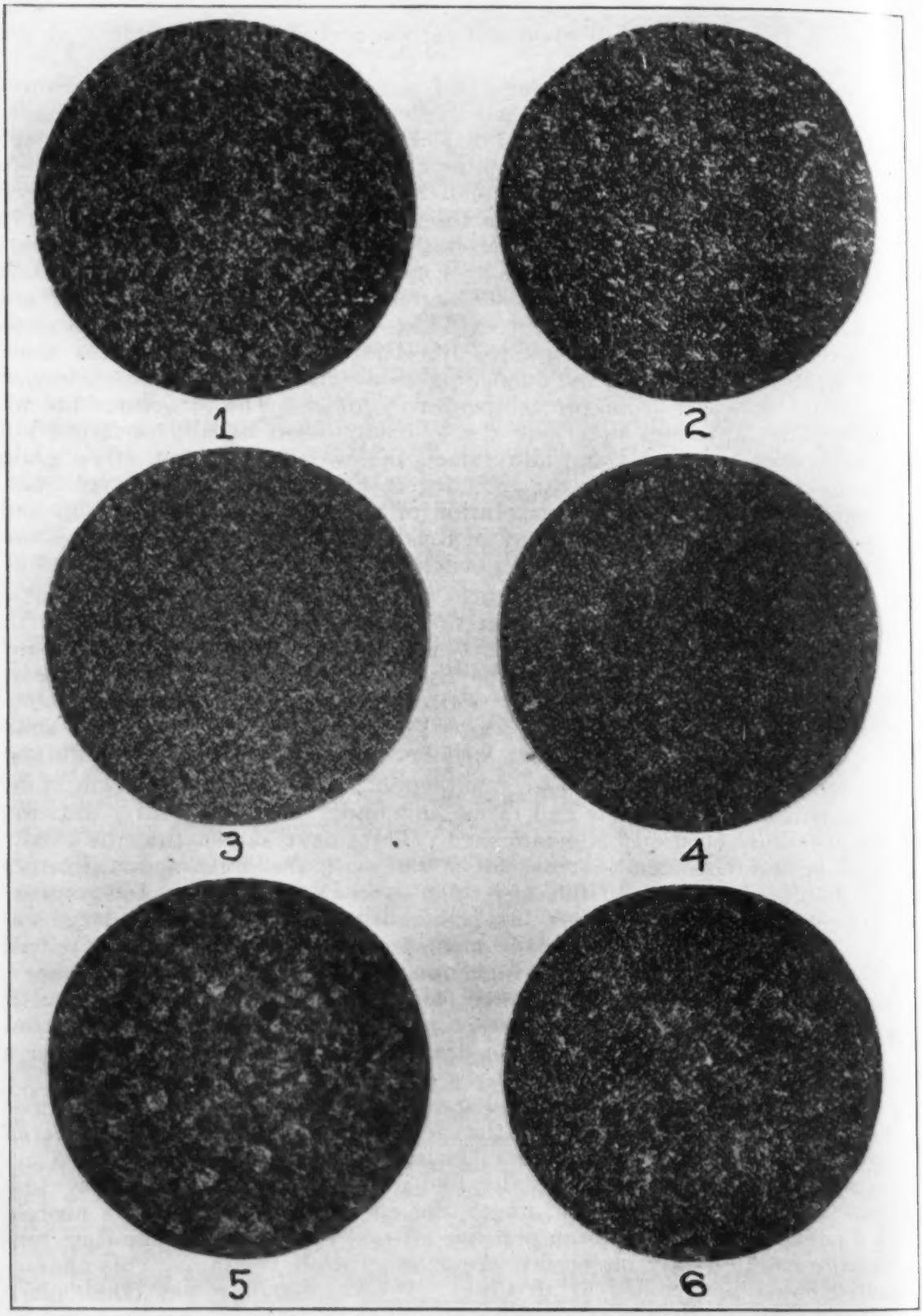
degrees Fahr., depending upon the carbon and chromium content of the steel.

Four knife blades were quenched in oil and four quenched in water to determine the difference in structure for stainless steel quenched in oil and water from temperatures of 1900, 1800, 1650 and 1600 degrees Fahr. On mounting, polishing, etching and examining at magnifications up to 500 diameters, no difference could be observed between specimens quenched in oil and in water from the same temperatures. Therefore only one micrograph is shown as characteristic for each of the four temperatures and these are represented by Figs. 1 to 4. Fig. 1 was quenched at 1900 degrees Fahr., Fig. 2 at 1800 degrees Fahr., Fig. 3 at 1650 degrees Fahr., and Fig. 4 at 1600 degrees Fahr. They are transverse sections etched in $FeCl_3$ acid and magnified 100 diameters. These specimens show the structures produced by quenching thin sections of stainless steel in either oil or water from the temperatures noted. The structures are all martensitic, although they lack the acicular form usually observed in quenched carbon steels and alloy steels of low alloy content. The grain size increases rapidly from the 1800 degree Fahr. to the 1900 degree Fahr. quenching temperature. The solution of the double carbide of iron and chromium is not complete at any of these temperatures, but is most complete after the 1900 degree Fahr. quench.

Figs. 5 and 6 show the structures of transverse sections observed at a magnification of 250 diameters in the blades quenched either in oil or water from 1900 and 1600 degrees Fahr. respectively. They were etched in $FeCl_3$ acid. The absence of the true acicular martensitic structure is evident in both plates. The only noticeable difference between the structures in these two figures is the larger grain size and more complete solution of carbides in the specimen quenched from the higher temperature.

Most low carbon steels in a hardened and undrawn condition show the elastic limit to be low and rather indefinite. It is only after drawing that a definite elasticity is established. Tests have shown that the elastic limits in stainless steel increase for a time with the drawing temperature and then begin to fall off like any other steel as the drawing temperature increases. Time limit enters into this phenomenon to a very large extent. A properly hardened blade must be drawn long enough to relieve the internal strains and this change must not be too rapid. The tempering colors appear in stainless steel at about twice the temperature of ordinary steel and are not altogether reliable. The writer is firmly convinced that the temper should be drawn to a definite temperature in a salt bath or an electric furnace.

The blades thus hardened and tempered are next taken to the grinding machines to be ground to the desired thickness and then tapered properly. Great care should be taken not to force this operation on account of the steel being unusually fine grained, and therefore very susceptible to that characteristic which the cutters call the grinders scorch. This particular kind of scorch polishes off easily but at the same time renders the steel directly under the scorch susceptible to stain. This characteristic must be avoided at all times. If any oxidation has taken place during previous operations, precaution should be taken at this point to see that it is thoroughly ground out for as has been said before any scale, no matter how small, will form a seat of corrosion which will invariably pass the inspectors and seldom show up until after the knives have been in use for a period of time. Following the grinding operation, the blades



Figs. 1-4—Transverse sections of stainless steel knife blades quenched from various temperatures in either oil or water. Etched in Fe Cl_3 acid and X 100. Fig. 1—Quenched at 1900 degrees Fahr. Fig. 2—Quenched at 1800 degrees Fahr. Fig. 3—Quenched at 1650 degrees Fahr. Fig. 4—Quenched at 1600 degrees Fahr. Figs. 5 and 6—Transverse sections of stainless steel knife blades quenched in either oil or water at 1900 and 1600 degrees Fahr. respectively. Etched in Fe Cl_3 acid and X 250. The only noticeable difference between structures is larger grain size and more complete solution of carbides in specimen quenched from higher temperature

are tested for temper, or in other words, they must stand an elastic limit of 1 to 5 inches. Stainless steel to be used for cutlery and to be in the most perfect condition should show a Brinell hardness between 525 and 550.

After the tempering test, the blades are glazed to remove all coarse grinding marks and this operation while simple requires an extra amount of work with a different grade of emery from that required for ordinary carbon steel. The knives are next taken to the inspection room where they are inspected to see if the glazers have removed all coarse grinding marks. The blades are then sent to the finishing room where the blades are mounted in handles. Here the backs, rims, points, bolsters, and necks are finished. The blade is then given the final glaze, and any other finishing touches needed to make it a first class knife.

The knife then goes to be tested for stainless qualities and if the blade is found to stain or copper plate after a two minute test with a concentrated solution of copper sulphate, the knife is rejected. After passing this test, the knives are etched and passed to the stock room ready for shipment. While there are some 40 operations through which these blades pass during their manufacture, only the high spots have been touched but they will give some idea of how this latest development in cutlery is manufactured.

In summarizing, it will be seen that the manufacture of a stainless steel blade, while not materially different in shape or size from that of an ordinary carbon steel blade. But the wear and tear on tools, furnaces, fires, extra operations, and rejections together with the extra price of stainless steel, which is seven or eight times the price of good carbon steel, makes the blade a very costly article.

It is interesting to know the test results of some of the different stainless steels that have found their way into the market. The writer has endeavored to take steels with wide difference in their chemical composition as to the two principal elements, namely, carbon and chromium. These samples were all forged at about 1700 degrees Fahr., and were hardened at different quenching heats according to their analysis, the quenching ranging from 1500 to 1900 degrees Fahr. These samples were all confirmed by three tests made up of concentrated solutions of acetic, tartaric and hydrochloric acids. The tests are as follows:

Steel No.	Carbon per cent	Chromium per cent	Stained in minutes	Cutting Efficiency
1	0.30	11.93	28	Satisfactory
2	0.20	12.21	35	Fair
3	0.40	12.60	13	Satisfactory
4	0.31	15.90	75	Satisfactory
5	1.10	23.32	43	Very good

Etching reagents used in grading stainless steel are: 1. Copper sulphate consisting of 4 grams of copper sulphate, 18 grams of sulphuric acid, and 90 grams of water; 2. Ordinary writing ink; and 3. Nitric acid having a specific gravity of 1.20. The time required for copper sulphate is 6 minutes, for writing ink 3 minutes and for nitric acid 2 minutes.

Discussion of Hall's Paper

MR. R. A. REIMAN: Do you have any trouble in the dies standing up in the trimming operations?

MR. HALL: No trouble, if the steel is well annealed.

MR. REIMAN: How about in the case of the 1.10 per cent carbon steel?

MR. HALL: The 1.10 per cent carbon steel is almost impossible to anneal, unless it is done hot.

MR. REIMAN: You do find difficulty in trimming in the case of the 1.10 per cent carbon steel?

MR. HALL: We have never been able to trim satisfactorily with 1.10 per cent carbon steel until we did it hot.

MR. REIMAN: What is the difference in the steel as compared with carbon steels so far as glazing is concerned?

MR. HALL: We have to give it an extra glazing. If you start in with the fine grain, you will find you are burning the surface and in burning the surface of the grain of steel it is very susceptible to stain.

MR. REIMAN: As compared to the carbon steel, how many operations do you make?

MR. HALL: Three.

MR. A. W. F. GREEN: Sometime ago I had the experience of going into a cutlery factory using both chromium for the stainless steels and the straight carbon steels. They found that they could not put the so-called "crocus" finish on the chromium steels. Can you tell me why that is so? By "crocus" finish, I mean the finish they put on by means of beeswax and glue on the wheel, mixed with red oxide.

MR. HALL: I don't think that is true; I think it can be done, although it is very difficult. If you file it down with the finest grade of emery which you can possibly get and get a fine bottom on it, it can be coated, although it is very difficult.

MR. GREEN: Do you know why it is so difficult?

MR. HALL: No, I don't except that the steel is so very fine grained and the color is hard to bring out.

MR. GREEN: Why does the steel with the larger grains, that is, quenched from 1900 degrees Fahr., when you have more or less of a large grain, so to speak, show a greater efficiency than one quenched at a lower temperature with greater grain refinement?

MR. HALL: The one that had the largest grain structures, Fig. 1 is not as good as the one under it, the one at 1800 degrees Fahr. as shown in Fig. 2. The one quenched at 1650 degrees Fahr. as shown in Fig. 3 will set. The 1800 degree Fahr. specimen did not set. You have to get them so that you can't set your blade, and in order not to set your blade you have to get your heat into it to make it a spring temper. I don't know why that is so, but I know it is so from practical knowledge; that is all I do know.

MR. REIMAN: What combination of steel, that is, as to carbon and chromium, do you find polishes best; or is there no difference?

MR. HALL: There isn't a great deal of difference; most of them polish about the same; they all polish high.

MR. A. L. DAVIS: Mr. Hall, what troubles do you have in hardening from a temperature such as 1800 degrees Fahr., which must render the blade

very soft, very pliable, and liable to be deformed; also, how about scaling?

MR. HALL: Stainless steel is very hard to scale anyhow. You can run that up into pretty high heat without making any perceptible scale on it. Keeping it in straight form is mostly in the tongs and the appliances that you use in the fire; they must not hit anything, and of course if they do they will bend.

MR. H. C. GOODWILL: Have you made any determinations up to date as to the ratio of stainless quality before and after heat treatment of stainless steel? In other words, stainless steel is, according to my understanding, presumably inherently stainless to a certain extent because of its composition. Have you any figures at all indicating whether or not that is so, and if so, what proportion of stainless quality it has as compared with the maximum after heat treatment?

MR. HALL: No, I have no figures. We have made tests along that line and have found that by polishing the steel it will stand quite a good deal of oxidation. I mean by that, it won't stain in any reasonable length of time. It will stain in time; but you will find much better results after it has been hardened.

MR. GOODWILL: What, to your mind, would be the stainless quality of the steel that had a content of about 0.10 per cent carbon, with the ordinary chrome commercial content?

MR. HALL: I don't know anything about it; we never tried any of it as low as that.

MR. A. E. BARKER: Can you tell me the Brinell hardness of those various steels at various temperatures?

MR. HALL: We have tested it, but I couldn't tell you offhand.

MR. BARKER: You couldn't tell whether the carbon steel quenched at 1900 degrees Fahr. gave a higher rating than that quenched at 1800 degrees Fahr.?

MR. HALL: The 1800 degrees Fahr. quench gave the highest rating.

MR. A. H. d'ARCAMBAL: What temperature do you draw your knives to?

MR. HALL: To about 650 degrees Fahr., for about 5 minutes.

MR. d'ARCAMBAL: Have you ever experimented with about a 0.60 per cent carbon, 0.40 per cent chromium steel?

MR. HALL: It will stain. You will find big blotches of stain on it. We used a copper sulphate test. Of course, everybody knows that you don't eat anything as strong as that, but we use is simply for a quick test, and we find that if it will stand two minutes of that, it will stand almost anything that goes on the table. We test every blade that goes out.

MR. D. S. WOLCOTT: I would like to know whether the results that you obtained from the forged blade would be verified if you tried out the double bevel blade? Have you experimented with both of them and tried the comparative merits of the two?

MR. HALL: You won't find any material difference if it is forged properly. You have to keep your heat up in forging; if you don't, you will get cracks. We use both.

MR. WHEELER: Has there been any effort to make carving forks, for instance, with stainless steel? Has that been successful?

MR. HALL: Yes, sir, they can be made very successfully and you can produce a very nice fork.

MR. REIMAN: Have you had any experience in making table cutlery out of rolled stock, sheet stock, not forged—the old method of making the table cutlery with the shape?

MR. HALL: Nothing, only in double bevel stock.

MR. HERBERT: You stated that you put the handle and the blade together after rough grinding, did you not?

MR. HALL: No, we glaze them twice before.

MR. HERBERT: What is the method of putting the handle and blade together, a soldering or welding process?

MR. HALL: Soldering in most cases.

MR. HERBERT: Have you had experience in welding this to a softer metal?

MR. HALL: You will find some difficulties, but it can be done.

MR. A. V. DeFOREST: Have any of these stainless steels better cutting quality than the ordinary carbon steels, and how is the cutting quality measured?

MR. HALL: I can't say that they are better, but they are fully as good. There are some that are not as good as carbon steel, but I think as a whole you will find that they are as good. I wouldn't say that they are any better.

MR. DeFOREST: How is the cutting quality measured?

MR. HALL: We test it out on cutting of a wooden stick, and we test it with a lathe and see how many shavings we can take off with one knife and then the other, before you have to hone it, or in other words sharpen it.

DISCUSSIONS OF PAPERS PRESENTED AT THE NEW YORK SECTIONAL MEETING

FOLLOWING are five of the stenographic reports of the discussions which were held after the presentation of technical papers read at the New York Sectional meeting, held in New York, March 3. The discussion of the paper "Stainless Steel in Cutlery Use" by R. G. Hall follows the paper published on page 561 of this issue of TRANSACTIONS.

Discussion of G. R. Brophy's Paper

This paper entitled "Calite—A New Heat Resisting Alloy" appeared on page 384 of the February issue of TRANSACTIONS.

MR. G. R. BROPHY: Calite is an alloy composed of iron, nickel, a small amount of chromium and aluminum, and depends upon its aluminum content for its heat resisting properties. It was brought out first purposely for carburizing boxes and containers, various heat treating containers, but numerous special applications have developed since, among these being its application in the manufacture of glass. It is probably the only alloy which can be used in the glass industry, that will not destroy the glass. There are also various chemical applications. The average operating temperature is about 1200 degrees Cent., however, it has been used at 1400 degrees Cent. without excessive oxidation—that was for a porcelain kiln.

Briefly, the physical properties of this alloy are:

Melting point, degrees Fahr.	2777
Softening temperature, degrees Fahr.	2500
Working temperature, degrees Fahr.	2200—2370
Specific gravity.	7.03
Weight per cubic inch, pounds.	0.25
Brinell hardness, annealed.	286
Scleroscope hardness, annealed.	40
Thermal conductivity, per cent of pure iron.	25
Transverse stress, 1-inch square bar, pounds per square inch.	4250
Tensile stress, pounds per square inch.	36,800
Coefficient of thermal expansion, 20—300 degrees Cent.	.0000157
Coefficient of thermal expansion, 300—600 degrees Cent.	.000014
Coefficient of thermal expansion, 600—900 degrees Cent.	.0000192

We were asked to determine the coefficient of friction on ground surfaces, the grinding marks running at right angle, of two pieces at room temperature. It was 0.189 at room temperature, 1.450 at 550 degrees Cent., and 0.714 at 700 degrees Cent. Then after running at about 700 or 800 degrees Cent. and measuring again at room temperature, the coefficient was increased to 0.352. Cast iron under the same conditions has about the same coefficient of friction as 0.352. The specific heat of calite is 0.120, of pure iron 0.110, and of steel 0.12, calite being the same as steel. We believe that the specific heat is of more importance in the ordinary container retort than the conductivity. The conductivity is low, it is true.

We have made various chemical tests on this alloy. We find it very resistant to atmospheric corrosion in the polished condition. Samples have been polished and exposed to the conditions of the salt spray test at 100 degrees Fahr. and after 200 hours there was absolutely no attack, the calite retaining its mirror polish. Iron oxide, under 1000 degrees Fahr. has no attack on calite; over 1000 degrees Fahr. the calite is attacked. Silicious slags attack calite. Most molten salts that we have tried out have practically no attack on calite.

Sulphuric acid of 25 per cent strength dissolves calite rapidly; hydrochloric very slowly and nitric hardly at all. After 48 hours in 25 per cent nitric acid, the metal lost 0.0004 grams per square centimeter exposed. Acetic acid has no effect. Molten carbonates, chlorides, nitrates, cyanides, lead, zinc, tin and type metal, sulphur and sulphur vapor do not attack calite. Exposed to SO_2 gas and steam, the first 24 hours there was an increase of about 0.11 grams. After 106 hours there was no appreciable increase in weight. Other non-corroding metals which were tested for the same length of time showed a gradual decrease in weight.

MR. G. L. NORRIS: Is calite supplied only in cast form?

MR. BROPHY: Yes, at present.

MR. NORRIS: What are the possibilities of it being developed for rolled, drawn and other shapes?

MR. BROPHY: We have experiments under way now, and there is a good possibility of their being successful. On the other hand, up to a short time ago it would have been practically impossible for us to work this material. It is machined only with great difficulty. It can be done, however. We can do it, but it is not a good commercial proposition.

MR. ARTHUR F. BRAID: Can you give us the analysis of that material, Mr. Brophy?

MR. BROPHY: It is composed of nickel, iron, chromium and aluminum.

MR. JOHN J. CROWE: Mr. Brophy, have you any figures on the physical properties of the material at higher temperatures?

MR. BROPHY: We have not as yet; we expect, however, to have them shortly and we will try to publish them.

MR. J. E. HALBING: Have you encountered any difficulties in making thoroughly homogeneous castings in fairly large liquid containers with comparatively thin sections?

MR. BROPHY: It depends entirely upon the size of the castings. We have successfully cast sections down to 3/16-inch thick; that is about the minimum. I don't know but what we have gone thinner than that. Yes, we have cast sections ⅛-inch thick, pyrometer tubes, which, as we all know, is not an easy thing to cast. As far as the uniformity of the material is concerned, we have had no complaints on that score so far. With good foundry practice we have no particular trouble, but it is a new alloy and our method of molding must be changed to fit the alloy. Many difficulties must be worked out even yet.

MR. E. L. MALONE: So far as oxidizing properties are concerned, how does calite compare with the other alloys on the market, for lead pot work, for case hardening work?

MR. BROPHY: Molten lead has no attack. We have run calite containing molten lead for 100 to 150 or 200 hours, or something of that sort, and have had no failures. For case hardening work we have had no particular failures, although some case hardening compounds show some attack, usually in the form of a green salt. I don't know how serious that is. The tests were not conducted perhaps a sufficient length of time to show its life under those conditions.

MR. HALBING: What is the longest life that you have obtained so far with calite?

MR. BROPHY: We have had few failures.

MR. HALBING: How long have you run your containers?

MR. BROPHY: Mr. Farr, can you answer that question?

MR. A. V. FARR: Between 1500 and 2000 heat hours so far, that is, on carburizing boxes.

MR. BROPHY: We have, for our own use, run carburizing annealing boxes for 1500 hours and they are perfectly good after that. We discontinued the test and put them in service and they are still standing up after about 18 months use. In smaller carbonizing boxes, using bone as a carbonizing material, they have been in service for 18 months without failure.

MR. WIZENAK: What kind of fuel do you use in connection with these tests just mentioned?

MR. BROPHY: These tests were conducted in oil-fired furnaces. In the annealing test I speak of, these boxes (see illustration on page 385 February TRANSACTIONS were supported on a container for annealing electrical sheets. It was an over-fired furnace, and those boxes shown are acting actually as baffles; the flame is striking right against the box itself. I am sure if there was any attack, it would be shown up there.

MR. WIZENAK: Is it a low sulphur content oil or a high sulphur content oil?

MR. BROPHY: That I don't know.

MR. A. L. DAVIS: What trouble do you have with warping or distortion?

MR. BROPHY: Absolutely none. After 1500 hours we have actually micrometered the boxes and found very little change except what will take place, of course, in building the oxide.

MR. DAVIS: No growth in size?

MR. BROPHY: No growth. In regard to that question of sulphur in the fuel, I doubt very much if high sulphur would have any effect on it, because we have heated this material in superheated sulphur vapor and while it was attacked, it formed a protective coating.

MR. WIZENAK: The reason for asking is that we have had some samples and we have used that at carburizing temperature with a high sulphur oil and it has not shown us any favorable results so far.

MR. BROPHY: I would like to know more about your conditions. I say we have had few failures; we have in one or two instances put out samples that have failed. Now, truthfully, that failure has been mysterious; we don't know why, but I am sure the temperature on oxidation had nothing to do with it. I am sure I don't know why these failures occurred.

MR. WIZENAK: As a word of explanation, it is only a small sample and I don't want to make that statement as anything against the alloy, because it is only based upon a small sample.

MR. BROPHY: I think possibly I can explain some of that. The first heats of this metal were made with a certain mold facing which we found afterward to have rather a bad effect on the material. Since then our mold wash has been changed and I think perhaps new samples obtained would show better results.

MR. ESTABROOK: I would like to ask, in your bending tests, regarding the tensile strength under heat conditions, particularly at the high temperatures, say, 1500 degrees Fahr.?

MR. BROPHY: Those tests are under way and are about to be made.

MR. MALONE: Do the boxes stand up under the salt spray test at high temperatures?

MR. BROPHY: They polished very well.

MR. A. H. d'ARCAMBAL: How would calite do for an electric furnace, where you want to hold a small tool?

MR. BROPHY: It could be used for that purpose, but I don't believe you think that that is a good service. I wouldn't say that it would stand it, although in working out the first experiments on this alloy we used that as a test. The alloy that would stand quenching in the neighborhood of 1200 degrees Cent. was the alloy that we chose. For a complicated section, I would dislike to quench it.

MR. d'ARCAMBAL: We will try one.

MR. WALTER AURAND: There is one point that you haven't mentioned, which is rather an important one in some of these high alloys, that is, the tendency of this casting to crack after it stands 3 or 4 hours in the box. Have you had any difficulty along that line? That is, the casting will not be scaled to any extent?

MR. BROPHY: We have had carburizing boxes, as I have said, in our own service, and we have had no trouble with cracking, in fact, to my knowledge we haven't had a failure of that kind and we have put out a considerable quantity of the alloy. We haven't had a failure from cracking. We have had a tube in operation for about three months, operating under conditions of about 900 degrees Cent. and holding considerable load. That tube was exposed, I believe, in three places, and the length of the tube is 13 feet, the diameter is 16 inches and has a 1-inch wall. I am sure it has a high tensile strength at high temperature because the tests we have made with it, other than tensile tests, have demonstrated that.

MR. MALONE: In your paper you mentioned the fact that at high temperature there is no attack on the material itself, after that first protective skin of oxide forms. You would say, then, that the metal would be good for a temperature of 1200 degrees Cent.

MR. BROPHY: We recommend using the alloy at about 1200 degrees Cent. and at about 2200 to 2300 degrees Fahr. It will stand higher temperatures, but of course with not as good life.

MR. ESTABROOK: Have you used this material in molten aluminum or molten brass?

MR. BROPHY: It won't hold molten aluminum. It will hold brass. We haven't had it holding brass; we have immersed samples in a bath of brass and there has been no appreciable attack, but aluminum goes right through it and lowers the melting point, so that the alloy will melt at a very much lower temperature. Antimony also attacks this alloy, but apparently with no bad effect; that is, the antimony alloys with it, it goes into the wall of the container, but with no bad effect.

MR. NORRIS: Referring to the attack of the antimony on the walls of these containers, does that have any effect in lowering or raising the temperature resistant quality of the metal?

MR. BROPHY: I imagine it would lower it. I really don't know. But when I said it had no bad effect, I meant the metal was still sound and strong. We did run for several hours after that attack and it had not oxidized appreciably.

MR. NORRIS: That mention of antimony reminded me of an article I saw a great many years ago to the effect that alloys of nickel, aluminum and antimony and iron had very high melting temperatures, and I was wondering when you mentioned the antimony content, whether it had any effect on the melting point.

MR. BROPHY: I don't know. I don't believe that would apply to all combinations of those elements. In the case of nickel aluminum, that compound melts at about 1600 degrees Cent., but, as is characteristic of all compounds, that is brittle as glass. It may be a similar case, that with the antimony it forms a high compound.

MR. PERCY WEDLAKE: Would you recommend using calite for protective tubes?

MR. BROPHY: We recommend it, but we don't like to cast around protective tubes.

MR. ESTABROOK: In your work on the zinc, did you notice any cracking in the zinc?

MR. BROPHY: I didn't notice it in the casting.

MR. B. H. DELONG: How does this metal stand handling in service? We have a tube for annealing steel; it is about 8 inches around and about 12 or 13 feet long. They roll out of the furnace while they are hot, say at 1200 degrees Fahr., and are dropped about 2 feet, which would knock off the protective coating in case they were brittle.

MR. BROPHY: What thickness of wall could that tube stand? If it were a thick wall, we would probably get away with it in good shape, but with a thin wall tube it would be difficult.

MR. BROWN: Have you any tests to show how this material stands up under high temperatures?

MR. BROPHY: Yes, sir. At 1300 degrees Cent. we have run calite for 216 hours in the open air without failure. After the 216 hours, we boosted the temperature to nearly 1400 degrees Cent. and ran it there for an additional 6 hours, and even after that there was no appreciable oxidation; the metal was sound after that. The nickel-chrome alloys, at 1250 degrees Cent. lasted 25 and 26 hours; two tests at 1250 degrees Cent. under the same conditions. As far as the amount of oxidation and the increase in weight is concerned, I will read from my original paper:

"On quenching after 100 hours at 1200 degrees Cent, calite lost but 0.03 gram per square centimeter exposed, while the best heat resisting base metal alloy other than calite lost 0.56 grams under the same conditions. The same samples were run at 1300 degrees Cent. for an additional 25 hours; calite lost 0.003 grams, the other 0.09 grams per square centimeter exposed." We have numerous other tests and they check that pretty well.

MR. W. M. MITCHELL: Might I ask under what conditions these tests were made?

MR. BROPHY: In the open air.

MR. MITCHELL: How were the temperatures taken?

MR. BROPHY: By lamp pyrometers.

MR. L. O. HART: Your results, Mr. Brophy, are taken from some casts we made. We took samples of calite and nickel chrome and put them in a quench running on tests of 1000 degrees Cent., and we found oxidation of calite at 1000 degrees Cent.

MR. BROPHY: Surely there is oxidation; there naturally would be, but that oxidation we depend upon for its protection. You mean you found excess of oxidation?

MR. HART: Yes.

MR. BROPHY: As I have said, we have had some failures; this alloy is not infallible; however, it is pretty good.

Discussion of V. E. Hillman's Paper

This paper, entitled "Cold Headed Bolts—Their Metallography and Heat Treatment," appeared on page 369 of the February issue of TRANSACTIONS.

MR. A. K. HAMER: I would like to say, Mr. Hillman, that we get a much better thread on our screws by annealing at 1150 degrees Fahr., than we do by annealing above 1150 degrees Fahr.

MR. HILLMAN: Very good results are produced at 1150 degrees Fahr. The only reason I didn't recommend it is because you are likely to get crystallization; isn't that true?

MR. HAMER: Yes, that is true, and we have found that we get a much better thread on bessemer steel than we do on basic. We find, of course, it is much harder on tools, but as far as the thread is concerned, we get a much better thread. The reason for this I don't know, whether it is the brittleness of the steel or what. These are wood screws I am speaking of.

MR. HILLMAN: I think that is to be expected because in your bessemer stock you have high sulphur and phosphorus, which promotes machinability. Of course, I will admit that with soft basic stock there is a tendency to tear, and you do not get the same machining properties as you would with bessemer steel.

MR. JOHN J. CROWE: Just what do you mean by crystallization? You say at the higher temperatures you do not get crystallization and at the low temperatures you do get crystallization. Does that mean the formation of grains?

MR. HILLMAN: By crystallization, as I have referred to it in this paper, is meant that you get an abnormal grain-growth if the metal is slightly strained and if you anneal within that hazardous zone. The micrographs which I showed, those that were taken of the large grains and of the smaller grains, were both taken of the same specimens. Crystallization in the wire industry is just simply, as I understand it, the creation of an extremely brittle condition in the metal, due to an abnormal grain-growth, and precisely the same condition takes place in both.

MR. CROWE: Don't you think it would be a little clearer is you used the term "grain growth" instead of crystallization?

MR. HILLMAN: I think so, yes; I gladly yield to that term. It probably would make it a little clearer.

MR. HOFFMAN: In all your annealing operations, then, I would take it that you carried them through the critical range, say 1650 degrees Fahr.; you didn't use any of the lower. You found in your work in cold heading bolts, that 1280 or 1300 degrees Fahr. was of no advantage; in other words, you got an absolute grain growth.

MR. HILLMAN: Yes; because in the same growth you are likely to have various degrees of distortion, and when your metal is critically strained and you anneal in this hazardous zone, you are likely to get you grain growth which will act as a seat of rupture only in that particular vicinity.

MR. A. W. F. Green: Why in annealing in the so-called hazardous zone of 1280 to 1550 degrees Fahr., do you get grain growth that is greatly strained? Is it because you have annealed the grain, or because of the relief of those zones, or what is it?

MR. HILLMAN: That is a peculiar characteristic manifested by all steels when the carbon is not above 0.20 per cent; sometimes not above 0.15 per cent. When you give it just a certain amount of strain and anneal

in that zone, you are going to get crystallization. In the wire industry if they drafted 12 per cent and annealed in this hazardous zone, they would get crystallization; isn't that right, Mr. Hoffman?

MR. HOFFMAN: In the wire industry they anneal at 1280 to 1300 degrees Fahr. and they don't get an absolute grain growth. The proposition is entirely different.

MR. GREEN: You have no theory to advance as to why it is so?

MR. HILLMAN: No, I didn't view it from that angle.

MR. GREEN: I simply asked the question for my own information.

MR. CRAWFORD: A few years ago Dr. Zay Jeffries performed some experiments on abnormal grain growth and found for every strain under 1280 degrees Fahr. in temperature there is a grain growth. I was wondering if it isn't possible that if you heat it at a lower temperature, your material strain at high percentages would grow. Have you noticed any other band or bands in a different position of your bolts than at these so-called critically strained parts? I don't believe there is any particular critical strain; I think that strain varies. You will get growth in different parts of the bolt, I believe. That is true of high sulphur steels, tungsten, molybdenum, ingot iron and a steel which we call standard iron which is an electrical steel.

MR. HILLMAN: Am I to understand that there is no place in steel at which you can depend upon this growth, no strain figure?

MR. CRAWFORD: For every strain below 30 per cent there is a temperature at which some part of the steel would grow. The rate of heating has an effect. If you heat rapidly, you will get growth in a very narrow band. In equiaxing you will get growth over a wider band. By heating rapidly, you don't give the steel an opportunity to recrystallize and you get a strain which is critical for the temperature at which you are heating.

MR. HILLMAN: You don't think that is a fixed quantity then?

MR. CRAWFORD: No. Of course, the question of large quantities of carbon will affect that; speaking of carbonaceous material for pure metal.

MR. HILLMAN: Briefly, what I understand by this grain growth is this: It is influenced first by the carbon content; second, by the amount of strain to which the metal has been subjected; and third by a treatment within a certain range, which is approximately 1280 to 1380 degrees Fahr.

MR. HOFFMAN: I believe. the treatment in this case applied to elongated grain structures. You have really wrecked your grain structures; you have an elongated grain structure which at 1280 or 1300 degrees Fahr. begins to reform, whereby you get a new structure. But that grain growth is not completed until you get to the critical point, which is in your case around 1600 degrees Fahr. You don't' have a complete grain growth at 1300 degrees Fahr., but you do have a beginning of the new structure.

MR. HILLMAN: You don't think the micrograph I showed was complete; it would have become larger?

MR. HOFFMAN: Not unless you carried them up to 1600 degrees Fahr. Several of them weren't complete.

MR. A. L. DAVIS: I think that this is a most interesting point; it is one that many of us have been up against at one time and another. In its reaction below the critical range of 1600 to 1650 degrees Fahr., mild carbon steel strictly can be compared with nonferrous alloys, where we have exactly that phenomenon of an abnormal grain growth developing in the case of slightly strained metals. For instance, of you take a piece of zinc and bend

and then heat it, you can see enormous grain form before your eyes; the temperature is so low that no oxidation takes place. It is a common characteristic in brass too.

In steel, as has been brought out, for every degree of deformation there would be a critical range in which abnormal grain growth would take place if heating was sufficiently prolonged in that range. Chappelle, by the way, shows this very well on pieces of a tensile test specimen which, on being pulled out, has elongated and has strained more and more as it decked down, and where it broke, has been most strained. Annealing in his case was 650 degrees Cent., which I think is somewhere around 1200 degrees Fahr. There was a certain range in that tapering test piece, representing different amounts of cold work, where the abnormal grain growth did take place. Had he annealed at some other temperature, that zone would have been moved up or down on the tapering section.

But I think you practically put your finger on the point when you say 1280 to 1380 degrees Fahr., because they represent the temperature conditions applying to a very slight degree of deformation, and it is in the case of slight deformations where abnormal grain growth will take place quite rapidly.

Departing from that for a moment, I wanted to ask about something that was not quite clear to me. In the refining and annealing by heating above the transformation temperature to 1650 degrees Fahr., you speak of annealing and quenching. Is that preferable to heating and allowing to cool naturally in air? I am asking as a matter of practical experience that you have had.

MR. HILLMAN: I think it is.

MR. DAVIS: You get possibly a greater stiffness, do you?

MR. HILLMAN: No, I don't think there is any response to the heat treatment, but it probably arrests the grain particles in some particular size.

MR. DAVIS: My reason for asking that question is this: While we know, of course, that mild carbon steels won't harden in any true sense of the word, when quenched from 1650 degrees Fahr., we do know that even with the lowest carbon steels there is a little tendency to show a greater hardness than measured by Brinell or Shaw, and unless I am mistaken, when such stiffened specimens are subsequently cold worked, they react very rapidly in their hardening, in their increase in hardness under the effect of cold work. I would have thought that there might be an advantage on that account, in allowing the annealed blanks to cool in air, rather than cooling in water. As I haven't actually carried this out commercially on that sort of work, I offer it in the sense of a question rather than a statement.

MR. HILLMAN: I would ask Mr. Hoffman to give us something in answer to that.

MR. HOFFMAN: The theory there is really arresting the growth in the critical range.

MR. HILLMAN: Is that what you do when you quench?

MR. HOFFMAN: Absolutely.

MR. ANCEL ST. JOHN: A very recent article by Dr. Jeffries which I think it is in the current number of *Chemical and Metallurgical Engineering*, throws considerable light on this question of crystallization, as Mr. Hillman has called it, or grain growth within a very restricted range. I have not read the article in question, but I am familiar with the subject matter of it. Dr. Jeffries shows that the temperature limits within which grain growth

occurs are very narrow, that is, they may be even narrower than the 100 degree range that Mr. Hillman has mentioned; that for any particular degree of working there is a particular temperature range within which the grain growth will be remarkably rapid and large grain size will be obtained in a very short time, whereas if you fail to heat to that temperature, you do not get the grain growth, or if you heat through that temperature, going through the zone too rapidly for any grain growth to occur, the growth does not occur at the higher temperature. Therefore, in this whole question it would be very desirable to obtain access to the data that Dr. Jeffries has made available. Probably you would find in it the answer to a number of your difficulties. It is the restriction within very close limits of the temperature at which the soaking is carried on.

MR. R. G. HALL: Mr. Hillman, I would like to ask what kind of steel you used in your dies?

MR. HILLMAN: I am not familiar with the steel that was used. I obtained the specimens from bolt manufacturers and consequently I am not in a position to state what their practice is.

MR. E. E. THUM: I would like to supplement what Mr. St. John has just said and call attention to some recent English work on the recrystallization of aluminum. It is rather far fetched, but it is merely another instance of a metal which is popularly supposed to be quite difficult to recrystallize, being in fact quite easy to crystallize if you had the proper amount of cold work and the proper temperature.

Professor Carpenter has been able to convert an entire test piece into a single crystal, and has done it not once but one hundred or more times. That is to say, a standard size test piece has been converted into a single crystal of aluminum, some 10 to 15 million times as big as the crystals which originally comprised the piece.

I would like to ask Mr. Hillman a question regarding his Fig. 15. There is a very curious lance-like structure shown there. This piece was etched with nitric acid, I presume?

MR. HILLMAN: No, copper ammonium chloride.

MR. THUM: You say that you polished that yourself for quite some time. Did you notice these lance-like structures early in the polishing?

MR. HILLMAN: No, I didn't notice them until afterwards.

MR. THUM: Why did it take so long to polish them? Ordinarily one would not expect to polish a sample for several hours before he got a sizable job, and I merely wanted to suggest that perhaps these lance-like structures would not polish out because they were caused by cold-working the rod before it got into your hands. Those lance-like structures are very much like cold-working figures which can be had and developed in ordinary low carbon steels by merely rolling them a little too cold, or finishing them a little too cold.

MR. HILLMAN: In this micro-etching, we first polish for an hour and etch, and if we do not get the pattern that we think we should get, we polish for another hour. I continued that polishing for 6 to 7 hours until I obtained that whirlpool-like appearance at the center of the head. It isn't always easy to develop these patterns the way they should be developed. I did not notice those lance-like structures until probably after the fifth or sixth polishing.

MR. DAVIS: Were you using a cold-drawn rod or an annealed rod?

MR. HILLMAN: It was basic soft, given one pass after the anneal.

In further reference to your question, this combination is developed by a combination etch and polish, so that is why we had to continue it until we got what we desired to get. It isn't as good a picture as I would have liked to show, but it is the best I could get under the circumstances.

MR. WHIGG: When you refer to the possibility of showing these etched figures in previously strained metal, I think there was a publication from one of the German technical magazines recently noticed in our press. I think it was found in December in the *Iron Age,* in which there were very carefully picked out details given, showing how it was possible to develop these etch patterns in strained iron and steel. The problem is of such interest that it is to be hoped that American metallurgists will look into the matter. I don't remember the details now, but as I recall the previously strained metal is given an anneal for from 20 minutes to 1 hour, then it is polished and etched with a modified Hines reagent. The bended strips and these cold worked strips develop certain definite measures which are susceptible of mathematical analysis as indicating the strain effects that have taken place in the members or the test piece.

As I say, I haven't had an opportunity yet to do any work on the method, but there is a possibility that it will open up new fields of investigation along certain lines—the examination of failed members, etc.

MR. DAVIS: You make a statement as to the effects of cold work in general, in which you speak of increased tensile strength, elastic limit, and so on, with decreased ductility. You mention specific gravity increasing with the working. I wonder if I might not take exception to that, that the density does not increase with cold work but decreases considerably. I think that it is a well sustained fact that most metals on cold work, unless they are spongy and porous to start with, become slightly increased in volume and therefore slightly less split up.

MR. HILLMAN: Aren't the crystals rendered more compact?

MR. DAVIS: No, I think actual experiment will show not. Cold-worked metals of all kinds tend to increase in volume rather than decrease.

MR. HOFFMAN: Then, Mr. Davis, I would understand you to say that if you had strained a low carbon steel through cold work or any other method, that you could not recrystallize that and get an original grain structure; is that the idea?

MR. DAVIS: No, I wouldn't say so, but in its cold worked condition it would be slightly less dense than it would be after you had reannealed it, or at the outset before it had been cold worked. It is contrary to the natural thought that any one would have on the subject, but I believe it is sustained everywhere by careful experimentation that specific gravity always decreases slightly as the result of very considerable cold work.

MR. HOFFMAN: Have your own experiments borne that out?

MR. DAVIS: Yes, in brass. I have not found it in steel, although I understand that is so recorded by scientific investigators.

MR. HILLMAN: Scientific investigators record that the specific gravity increases in steel.

MR. DAVIS: The specific gravity of hot worked steel over that of cast, but not when you come to cold work.

MR. WIZENAK: Regarding that proposition, I had that point taken up with Professor Sauveur of Harvard, recently, and he bears out Mr. Davis' statement. It was also contrary to my own belief. I had a class and

that question came up, and it was surprising to come across that problem. I took the question up with Professor Sauveur and he made a statement to that effect. It does not seem to be consistent with general belief, but nevertheless that is the opinion of Professor Sauveur.

Discussion of J. H. G. Williams' Paper

This paper, entitled "Perfecting a Drop Forging," appeared on page 391 of the February issue of TRANSACTIONS.

MR. W. H. SAWTELL: I would like to inquire how the flash traveling back into the stock was overcome from the stock in the center of the pieces?

MR. WILLIAMS: We were going to change the shape of the edger impressions, but in the meantime the man on the hammer omitted the use of the edger impression and put the bar stock directly into the roughing impression. He found the blank was not thrown; in other words, all the money that we had put into the sinking of these impressions was money thrown away. The hammer man himself overcame that defect by omitting the edger impression.

MR. SAWTELL: How about the part out near the edge of the center?

MR. WILLIAMS: I should have mentioned that. There are three ways of overcoming that defect. In the first place, you can punch out the central part before the final blow and make room for the excess metal to flow into; or you can, in your rough forging operation forge the center thinner than we did in this case, so that there would be a space left when the finishing impression came down for the metal to flow into. As a matter of fact, we cut a gutter in the finished impression, in the central part of the finished impression, thereby creating a space for the excess metal to flow into, and that would be the ordinary procedure in a case of that nature simply make some provision for affording extra space for the metal to flow into.

MR. A. H. d'ARCAMBAL: To what extent do you use a deep-etch test in inspecting incoming material?

MR. WILLIAMS: That depends considerably upon the forging upon which we are going to use the steel. If the forging is a steam hammer job or a job for a heavy hammer where the hammer expense itself is heavy, it is naturally an expensive operation to make forgings and reject them. In cases of that sort we have developed a rather elaborate inspection system, which involves the pickling of a representative number of bars for outside service inspection and also, particularly on jobs with the steam hammer, of cutting a few slabs, usually about one-half inch thick, we will say, two or three to a heap, and subjecting them to the deep-etch test. We find that this test is invaluable in catching stock which is segregated, stock in which the sulphur has not been properly disseminated, dirty steel, and steel which lacks homogeneity.

MR. d'ARCAMBAL: Do you have much trouble having the steel mills take the stock back when you deep-etch?

MR. WILLIAMS: No, we never have any trouble. As a matter of fact, we buy what is called double selected stock. I would say that double selected merely means, from my own observation, that if you

find something wrong, you have the privilege of selecting it, whereas if you bought mill run, you take a gamble.

MR. d'ARCAMBAL: There is quite a difference, of course.

MR. WILLIAMS: Our treatment has been very satisfactory, that is, the treatment given us by the steel company has been very satisfactory.

MR. R. H. REIMAN: Do you make the breakdown operation and the finishing operation in the same die, that is, on the same block and in the same heat?

MR. WILLIAMS: Usually, yes. Of course, the size of the forging and the shape of the forging controls that. In a crankshaft forging probably you would make your breakdown under a hydraulic press, at least we do, and our rough blanking forging under one steam hammer and the finishing impression under another steam hammer. When you get into this heavy steam-hammer work, it is rather hard on the piston rods to put any heavy duty on an impression which is over the edge of the dies. It throws a side strain on the rods.

MR. REIMAN: What do you do in this particular case. (Designates a particular forging).

MR. WILLIAMS: The three impressions are on one set of the dies; the breakdown on the edge, the roughing impression on one side and the finishing impression on the other side. It is quite a question in shop economics sometimes to decide whether you will use one impression, two impressions or three impressions. Many factors are to be considered. If you have a long run, naturally you want to save your finishing impression as long as you can and throw the wear into your roughing impression. If you have a short run and no chance of a repeat order, you want to hold your die cost down and you make it a one impression job.

Discussion of E. J. Janitzky's Paper

This paper, entitled "New Development on the Influence of Mass in Heat Treatment," appeared on page 377 of the February issue of TRANSACTIONS.

MR. JANITZKY: The author desires to supplement the information given in the original paper. This additional information belongs properly after the second paragraph on page 377 ending with the words "and outside of rounds on their cross sections."

In regard to this, it may be said that this holds good not only for ordinary structural steels, but also for air hardening steels. The paper does not contain that fact, but further experiments revealed it.

A second substitution should be made after the fourth paragraph on page 377 ending with the words "a multiple of the square of the hardening capacity."

It has been found that in some air hardening steels the factor is 9; in certain others it is 7, but for ordinary structural alloy steels, it seems to be 2.

Data regarding the air hardening steels mentioned in the paper is given in the following two tables:

(1). *High nickel-chrome steel quenched in water at* 1510 *degrees Fahr.*

The composition of the steel was carbon 0.29, manganese 0.37, nickel 2.22 and chromium 0.97 per cent.
$BM = 512$, $b = 196$, thus

$$n = 7\left[\frac{BM}{b}\right]^2 = 47.7$$

$$B = \frac{(14.125)\ (47.7)}{D - (-1.255)} + 196$$

Center Data

The following results were obtained:

Diameter of section inches	Actual Brinell Hardness	Calculated Brinell Hardness
0.5	512	...
0.875	...	512
1.0	495	495
2.0	418	403
2.5	387	376
5.0	...	294

(2). *High nickel-chrome steel, S.A.E. specification* 3440, *quenched in water at* 1450 *degrees Fahr.*

The composition of the steel was carbon 0.42, manganese 0.30, nickel 3.18, and chromium 0.81 per cent.
$BM = 555$, $b = 197$, thus

$$n = 9\left[\frac{555}{197}\right]^2 = 71.35$$

$$B = \frac{(71.35)\ (14.125)}{D - (-1.47)} + 197$$

Center Data

The following results were obtained:

Diameter of section inches	Actual Brinell Harnesss	Calculated Brinell Hardness
0.5	555	...
1.0	546	...
1.35	...	555
2.0	487	487
3.0	420	422

MR. JANITZKY: Referring to Sir Robert Hadfield's criticisms appearing on page 396 of the February issue of TRANSACTIONS, Mr. Hadfield says that I took a physical basis as my hypothesis. I dont see where I could have taken any other one. Should I have taken a metaphysical one? I could it has been proven that the important factor in heating, cooling and hardening is the surface. That is the reason I took a physical basis, a real one, which can be measured and from which there can be obtained a definite idea about things that have some connection with hardness.

In the second place, he says he doubts whether the Brinell hardness de-

creases with increase in surface according to a straight line. I can say definitely that if you plot the Brinell hardness against the surface in pounds per square inch, you will get a straight line. As long as he questions it, he should not just simply shake his head, but should bring evidence that I am wrong.

I think the proof of the pudding is in the eating. I have given figures for alloy and air hardening steels that check wonderfully. I don't think that we need to be in doubt about this question in regard to the direct ratio between Brinell and surface.

I can't understand exactly what Mr. Hadfield means regarding his figures, namely, "water quenched value of b=214.4, and water quenched value of d=0.49." We could take the annealed condition of b for every steel, but as I stated in the paper, our calculations show that for engineering purposes, the formula works better if b is taken as the hardness of the steel in the normalized state.

In regard to d I would like to say that everybody knows that a hyperbola has two asymptotes, and therefore, d and b are essential parts of the formula, as both represent the asymptotes of the curve. I can't figure a hyperbola without a d. Further, d is not an assumed proposition; it is a function of n, and n we know is the function of the hardening capacity and changes in multiples in connection with the sensitiveness of the steel. These factors have to be exploited and constants found which will work on an engineering basis. A criticism of d is superfluous.

Further, Mr. Hadfield has said that he hopes that others will investigate the subject. It is hoped that someone else will investigate my data and offer criticism based on actual experiments.

I wish to call attention to an error in the printing of the paper. On page 381, in the first table on the page, the figure for the "Actual Brinell hardness" of the 3-inch round should be 248, instead of 348.

Discussion of A. V. deForest's Paper

This paper, entitled "Magnetic Testing of Small Case Hardened Chain," appeared on page 387 of the February issue of TRANSACTIONS.

MR. A. V. DEFOREST: Toward the beginning of the war there was a pleasing picture in *Punch*, depicting a corps of German professors testing war bread, and the first test was its rust resisting properties in sulphuric acid, and the next one was its electrical conductivity at 100 degrees, and then they measured its properties as an insulator, and after that they carried it up to the top of the building, dropped it off and found out how long it took to reach the ground. Now, those tests were supposed to be humorous, but if you go back a step further than that, you get the basis for the tests I am going to show you.

We have, more or less, two different types of tests: The type which approximates working conditions and which therefore gives properties that are directly interesting—the tensile test and the shock test and sometimes the hardness test are all of that class. Then there is another class of tests which were evidently the ones that the German professors were trying—a test which measures something or other, which does not necessarily have any connection whatever with the use to which the material is

to be put, but yet which varies with some property of the material which does influence its usefulness.

There are infinite properties belonging to most materials; there are all sorts of things that can be measured in regard to almost anything, and there is a possibility of using any one of those, if it happens to coincide with a useful change in the material. This magnetic affair is of no particular interest to hardened cross chain; nobody uses hardened cross chain in electrical machinery, but nevertheless it happens that the magnetic qualities change very closely, proportionately, to a particularly useful quality in the chain.

We found, on looking over chains that had worn, that both those that were too deeply cased and those that were too little cased were unsatisfactory. The too deep case is so brittle, it may break long ahead of its proper life; the too soft one will wear out after a fair length of life but before the proper one. Therefore we were interested in getting the right depth of case and knowing it.

The previous method of breaking the link, of looking at it and guessing from its appearance how deep the case was, is not particularly satisfactory; it limits the amount that can be examined and it takes too long and it costs too much, for a real, proper check. When we got a method that would do that quickly and non-destructively, we found that we could raise our quality very much indeed simply by having a test that worked rapidly and with a sufficient degree of accuracy.

Why the thing works, I don't know, and it seems almost beside the point. The relation is simply that it has been established by practical tests that it does measure something which is akin to the life of the chain. With one test only, that is, measuring on a single scale with a single arrangement of circuit, you get a reading which does not necessarily mean a particular depth of case; it varies with the carbon of the base stock and with the heat treatment that it has received, whether it is quenched from the pot or whether it is cooled and reheated and quenched again, but it is more or less proportional to the hardness or to the brittleness, if we like to say that, and to the wearing ability of the chain.

MR. A. H. d'ARCAMBAL: How would a chrome vanadium steel around 0.40 per cent carbon serve for skid chains? I think you could quench and get a better wearing.

MR. DEFOREST: So far we haven't obtained enough service to pay for the cost of welding, that is, to pay for the better stock and for the welding. After we have made our chain of that, it does not wear enough to pay the extra cost of the stock itself.

MR. d'ARCAMBAL: Of course, your heat treating proposition would be much better than the carburizing.

MR. DEFOREST: That is true, but the heat treating itself does not seem to work out better in the results, from the work we have done.

MR. A. L. DAVIS: Have you ever tried the 13 per cent manganese steel?

MR. DEFOREST: We have tried that without the success which we had hoped for. After the labor and difficulty involved in getting that into a chain, it does not do what it is expected to do, although I find it is recognized that the steel, if it is punished hard enough, will wear about like ordinary low carbon. On the road it behaves very much like a 0.10 per cent carbon steel without any carbonization at all.

MR. C. O'NEILL: Have you tried the 1.25 per cent manganese steel that was used for the cast steel chains during the war?

MR. DEFOREST: I don't think we have tried that. It would be interesting.

MR. O'NEILL: There have been some very interesting results on chain of the composition that I mentioned.

MR. DEFOREST: It is rather interesting if you can get it in the shape so that you can handle it. It is rather difficult to handle, I believe.

MR. F. P. FAHY: May I refer to a point in your paper? It reads: "So far, the magnetic result has given a pretty close idea of brittleness of the chain, whatever that may mean. If now another variable is brought in, the drawing temperature results are not as good." I would like to inquire whether that means that this particular apparatus is not workable if this additional variable, the drawing temperature, is brought in?

MR. DEFOREST: We have made magnetic tests on this principle, in which we were interested in the drawing temperatures and in which we did measure them separately from the other state of the steel. It is not quite as simple or as easy as this thing is. Naturally, it means two measurements instead of one, we are going to find out two things instead of one, and if one, as in this case, does the trick, we are well pleased. It can be done. We are doing it.

MR. W. F. GRAHAM: Regarding the application of this method of magnetic testing to a straight carbon tool steel, of a sufficient section that would not harden all the way through, I was wondering if your method would give you an indication of its hardness or its brittleness. If the outside skin of the metal was sufficiently hard for our purposes, if a straight carbon section of sufficient carbon steel would not have a martensitic zone and then the interior would not be martensitic, could you get any indication on material of that kind?

MR. DEFOREST: I believe we could if we had all the factors except the one remain constant.

MR. W. H. SAWTELL: Do I understand that tools of high carbon steel can be tested by this process?

MR. DEFOREST: Very readily.

MR. SAWTELL: Practically any hardness of any sort of steel?

MR. DEFOREST: Yes.

MR. SAWTELL: Some tests, I imagine, have to be run originally, to get the material to work from.

MR. DEFOREST: You have to compare with standards that have to be the high ends to whatever limit you like and the low end to whatever limit you like, but simply use it as a no-end gage.

MR. SAWTELL: It would seem to me that that would have a large use, then, in the steel trade.

MR. DEFOREST: I hope that it will.

MR. E. F. CONE: In working with magnetic testing, have you been able to correlate any other physical properties besides hardness, or do you think it would be possible to do that?

MR. DEFOREST: That is quite a question. We have been able successfully to arrange the test to fit several different factors in the usefulness of the steel the tensile strength, we will say, and the elongation are mutually dependent, but not necessarily exactly so, because you can have a certain tensile strength with and without a certain elongation, depending on the other factor, the composition of the steel. We can handle

up to two factors we know about. The others are a bit vague and it becomes very complicated when you try to handle three factors at once. However, there is no reason why it can't be worked out. We can't go to the magnetic test and pick out hardness or tensile strength or brittleness, or anything else directly; we have to take an aggregate of factors and in some way fit a test to the particular results that we want, knowing the results beforehand from working tests.

MR. P. R. LAFORE: A few minutes ago there was some mention made of costs of the process of case hardening. I wondered what method you used, whether you pack or use some other method?

MR. DEFOREST: These are case hardened in one of the numerous compounds.

MR. LAFORE: Do you use a furnace?

MR. DEFOREST: We use a furnace.

MR. LAFORE: Is it practical?

MR. DEFOREST: It is a practical way to do it, especially if you desire uniformity.

PHYSICAL TESTS ON HIGH SPEED STEELS

By A. H. d'Arcambal

A SEARCH of the literature on high speed steel, shows that very little information has ever been published on the strength of high speed steel given different heat treatments. Believing that such information is of sufficient value to merit work along these lines, the writer recently has completed a series of tensile and transverse tests on the two classes of high speed steel finding the widest use in this country, namely, the 18 per cent tungsten, 1 per cent vanadium type and the 14 per cent tungsten, 2 per cent vanadium grade.

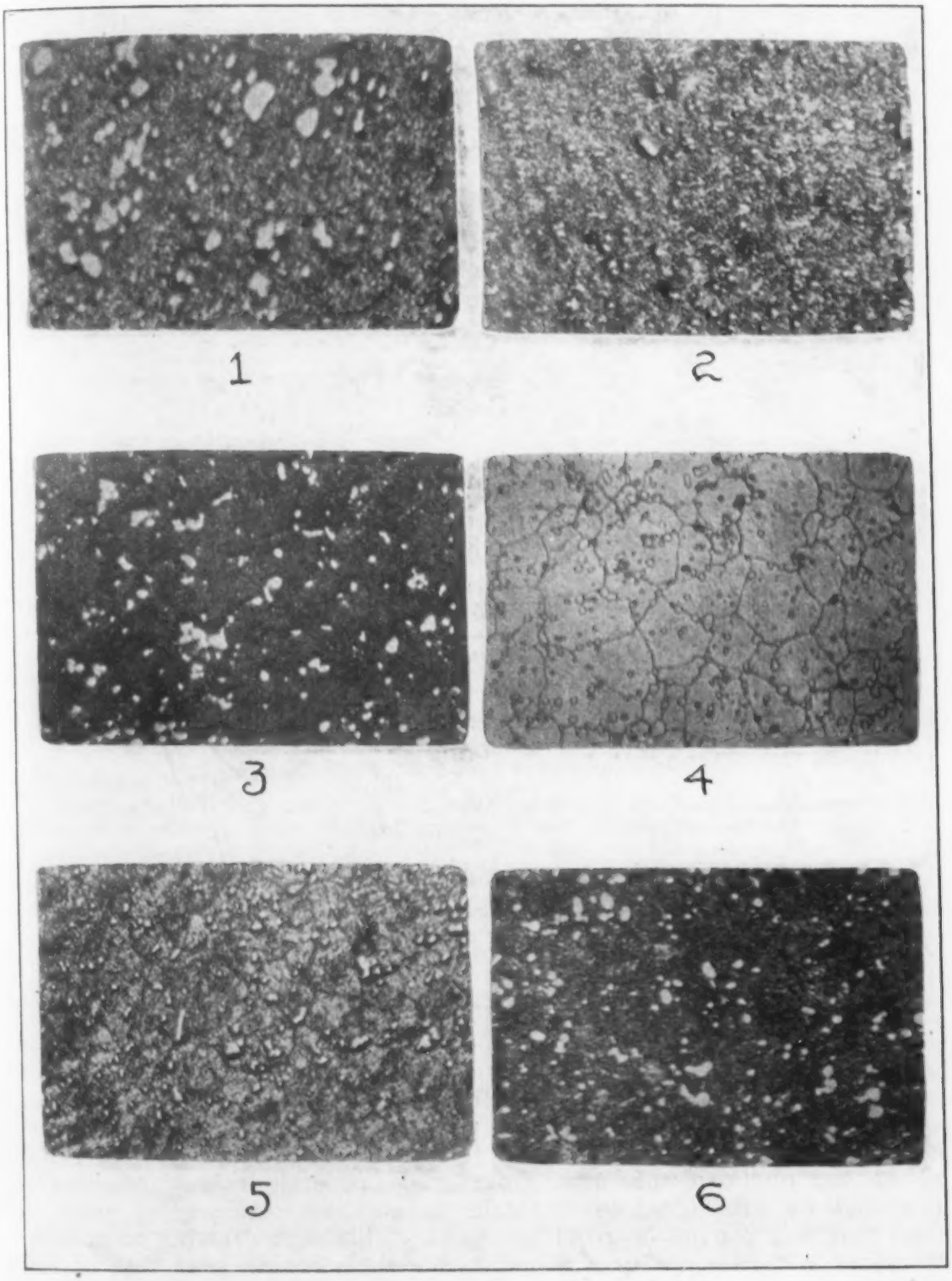
Hot rolled and annealed bars ¾-inch round were used for the transverse specimens, the analysis of the material running as follows:

	Grade *A* per cent	Grade *B* per cent
Carbon	0.63	0.65
Chromium	3.55	3.33
Vanadium	0.97	1.78
Tungsten	17.04	13.85

These bars were cut into 7-inch lengths, centered, and turned to 11/16-inch in diameter. They were given the different heat treatments shown in Table I, then carefully ground to 21/32-inch diameter. The transverse figures obtained on these different specimens are shown in Table I and the micrographs in Figs. 1-17. The fractures were also examined, and it was noted that the fractures on the specimens of grade *B* steel, quenched from 2350 degrees Fahr. showed a slight coarsening of the grain; the fractures on the grade *B* samples quenched from 2100 degrees Fahr. and all of the grade *A* specimens possessing a velvety appearance. All of these transverse samples were also tested for hardness, using flat temper testing Nicholson XF files. The only specimens too soft to the file were the samples of grade *A* and grade *B* steels quenched from 2100 degrees Fahr. and given the 1100 degrees Fahr. draw. One is led to draw the following conclusions from these tests:

1. The heat treatment giving the greatest fiber stress together with the requisite hardness was that of quenching from 2350 degrees Fahr. into the lead bath at 1100 degrees Fahr., cooling to room temperature, and drawing to 1100 degrees Fahr. Quenching from the high temperature into an oil bath, and drawing to 1100 degrees Fahr., gave almost as high results as the specimens quenched into the lead bath, and given the high draw. On tests conducted several months ago, transverse specimens made from high speed steel similar in analysis to grade *A* steel, were quenched from 2300 degrees Fahr. into oil and drawn to 1100 degrees Fahr. These specimens gave a fiber stress of 550,000 pounds to the square inch, two and one half times the strength of samples from the same bar quenched from the same temperature, but only drawn to 450 degrees Fahr. The author believes that if the specimens quenched from 2350 degrees Fahr. had been drawn to 1150-1175 degrees Fahr., the fiber stress obtained on the grade *A* steel would have approached quite closely the strength of the samples given the 2300-1100 degree Fahr. treatment, and would also have possessed the necessary hardness, because of the higher quenching temperature.

A paper presented at the Indianapolis Convention. The author, A. H. d'Arcambal, is chief metallurgist, Pratt & Whitney Co., Hartford, Conn.



Figs. 1-6—Micrographs of grade *A* transverse series. Etched 3 minutes in 5 per cent nital and X 465. Fig. 1—Longitudinal section, annealed condition. Fig. 2—Cross section, 2100 degrees Fahr. oil quenched, not drawn. Fig. 3—Cross section, 2100 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr. Fig. 4—Cross section, 2350 degrees Fahr. oil quenched, not drawn. Fig. 5—Cross section, 2350 degrees Fahr. oil quenched, drawn to 450 degrees Fahr. Fig. 6—Cross section, 2350 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr.

2. Specimens of grade *A* steel, quenched from 2350 degrees Fahr. into oil and not drawn and samples quenched from the same temperature into the lead bath at 1100 degrees Fahr., air cooled and not drawn, showed a fiber stress of only a little more than one-half that of specimens given the same quenching treatment but drawn to 1100 degrees Fahr. Some of the undrawn specimens developed small cracks after grinding, due to the strains in the material. Every specimen made from grade *B* steel, and quenched from 2350 degrees Fahr. into oil or lead and not drawn,

Table I

Transverse Stress Tests

Analysis of Material Used

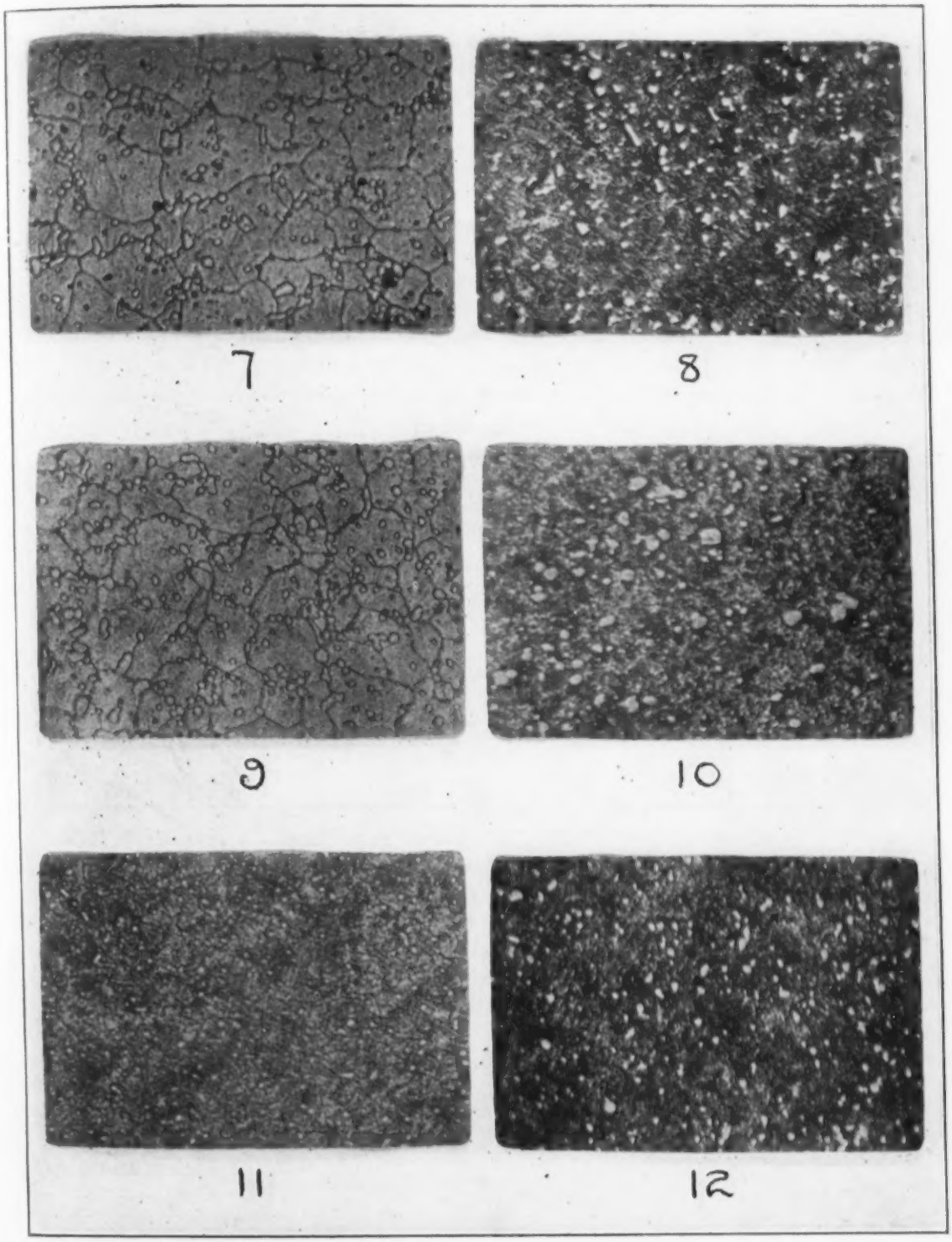
	Grade *A* per cent	Grade *B* per cent
Carbon	0.63	0.65
Chrominum	3.55	3.33
Vanadium	0.97	1.78
Tungsten	17.04	13.85

Specimens—0.656 inch diameter x 7 inches long.

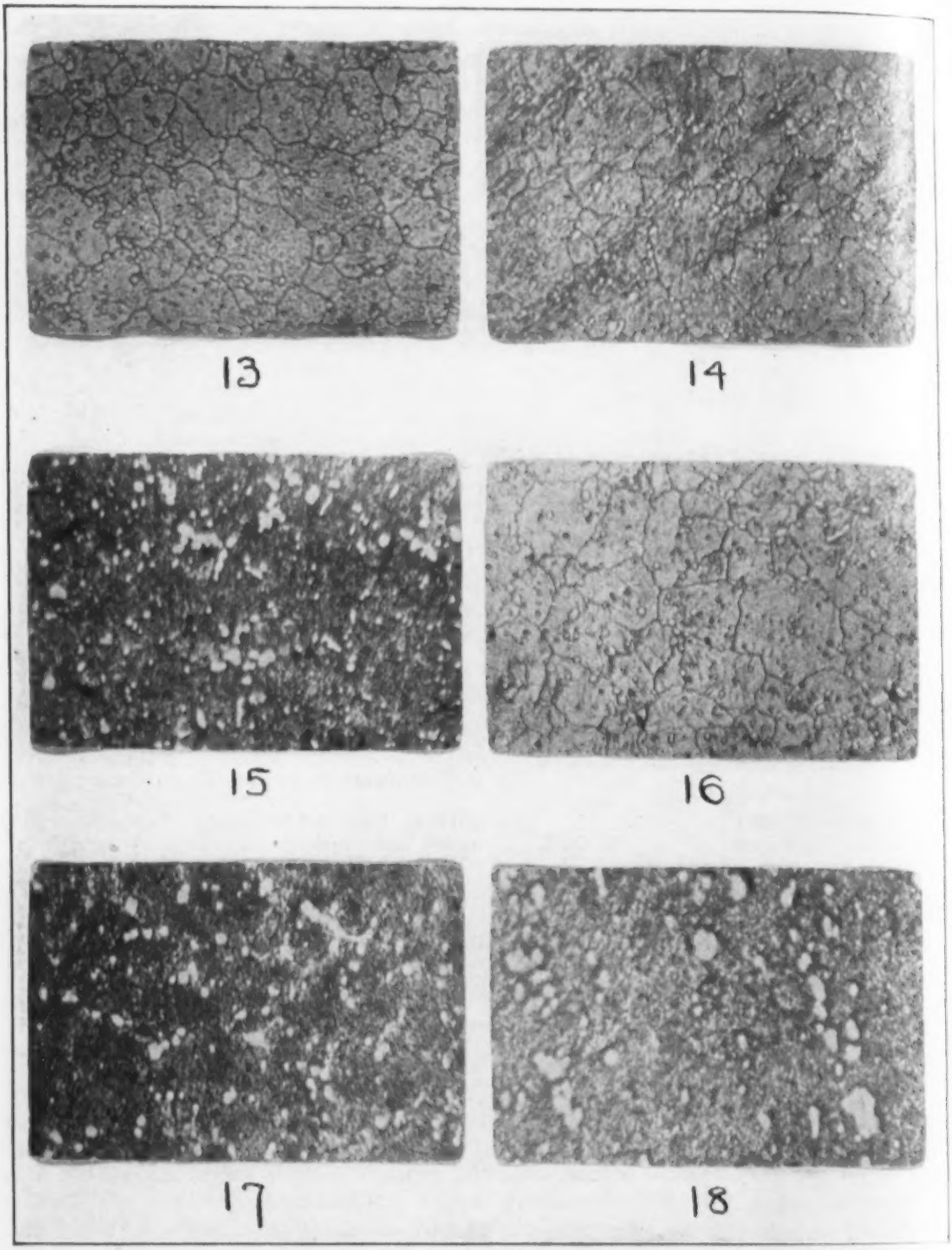
Heat Treatment	Approximate Fiber Stress Grade *A* pounds per square inch	Grade *B* pounds per square inch
2100 degrees Fahr. Oil quenched, not drawn	302,000	330,000
2100 degrees Fahr. Oil quenched drawn to 1100 degrees Fahr.	460,000	520,000
2350 degrees Fahr. Oil quenched, not drawn	250,000 Few small grinding cracks present	Full of grinding cracks, so not tested
2350 degrees Fahr. Oil quenched, drawn to 450 degrees Fahr.	308,000	222,000
2350 degrees Fahr. Oil quenched, drawn to 1100 degrees Fahr.	401,000	378,000
2350 degrees Fahr. Quenched into lead at 1100 degrees Fahr. then air cooled. Not drawn	243,000	Full of grinding cracks, so not tested
2350 degrees Fahr. Quenched into lead at 1100 degrees Fahr. air cooled then drawn to 1100 degrees Fahr.	432,000	396,000
2350 degrees Fahr. Quenched into oil until spec. was cooled to about 1100 degrees Fahr. then air cooled. Not drawn	243,000 Few small grinding cracks present in one of the specimens.	

developed so many grinding cracks that they could not be tested. The undrawn specimens of both grades of steel were ground with the utmost care, for from tests conducted in the past, it was discovered that the specimens given the high quenching temperature, 2300 degrees Fahr., and not drawn all cracked in grinding. It was impossible, however, to grind all of the undrawn specimens from grade *A* steel without cracking a few, and we were not able to obtain an undrawn specimen of grade *B* steel that was not full of grinding cracks. This high drawing treatment, therefore, not only produces about double the strength over that of undrawn specimens, but also gives a greater factor of safety in grinding.

3. Grade *B* specimens quenched from 2350 degrees Fahr. and drawn to 450 and 1100 degrees Fahr., do not possess as high a transverse strength as grade *A* specimens given the same hardening treatments. It would appear that grade *B* steel does not stand as high a quenching temperature as grade *A* steel, for the fracture on the grade *B* specimens,



Figs. 7-9—Micrographs of grade *A* transverse series. Etched 3 minutes in 5 per cent nital and X 465. Fig. 7—Cross section, 2350 degrees Fahr. quenched in lead at 1100 degrees Fahr., then air cooled, not drawn. Fig. 8—Cross section, 2350 degrees Fahr. quenched in lead at 1100 degrees Fahr., air cooled then drawn to 1100 degrees Fahr. Fig. 9—Cross section, 2350 degrees Fahr. quenched in oil until cooled to about 1100 degrees Fahr., then air cooled, not drawn. Figs. 10-12—Micrographs of grade *B* transverse series. Etched 3 minutes in 5 per cent nital and X 465. Fig. 10—Longitudinal section, annealed condition. Fig. 11—Cross section, 2100 degrees Fahr. oil quenched, not drawn. Fig. 12—Cross section, 2100 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr.



Figs. 13-17—Micrographs of grade *B* transverse series. Etched 3 minutes in 5 per cent nital and X 465. Fig. 13—Cross section, 2350 degrees Fahr. oil quenched, not drawn. Fig. 14—Cross section, 2350 degrees Fahr. oil quenched, drawn to 450 degrees Fahr. Fig. 15—Cross section, 2350 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr. Fig. 16—Cross section, 2350 degrees Fahr. quenched in lead at 1100 degrees Fahr., then air cooled, not drawn. Fig. 17—Cross section, 2350 degrees Fahr. quenched in lead at 1100 degrees Fahr., air cooled, then drawn to 1100 degrees Fahr. Fig. 18—Micrograph of grade *A* tensile test series. Longitudinal section, annealed condition. Etched 3 minutes in 5 per cent nital and X 465.

quenched from the high temperature, showed a slight coarsening of the grain. The author believes that grade *B* specimens quenched from 2300 degrees Fahr. and drawn to 1100 degrees Fahr. would show at least as great a strength as grade *A* specimens given the 2350-1100 degree Fahr. treatment.

4. The micrographs, Fig. 1-17, show that the material as received in the annealed condition, was satisfactory. Specimens of both grades of steel quenched from 2100 degrees Fahr. and not drawn showed a fine grained martensitic structure with free carbides and tungstides. Drawing to 1100 degrees Fahr. into oil or lead and not drawn possessed the polyhedral structure of austenite with only a few undissolved carbides and tungstides. Drawing to 450 degrees Fahr., in case of the *A* grade, leaves only a trace of the polyhedral structure, while the *B* specimens still showed a well developed grain. It would thus seem that the *B* type

Table II

Additional Tensile Tests

Grade *A* High Speed Steel

Heat Treatment	Temperature at which tested, degrees Fahr.	Tensile strength pounds per square inch
2350 degrees Fahr. Oil quench, not drawn	Room temperature	175,000
2350 " " " " " "	800	272,000
2350 " " " " " "	1100	225,000
2350 degrees Fahr. Oil quench, 450 degrees Fahr. draw	Room temperature	185,000

Carbon Tool Steel

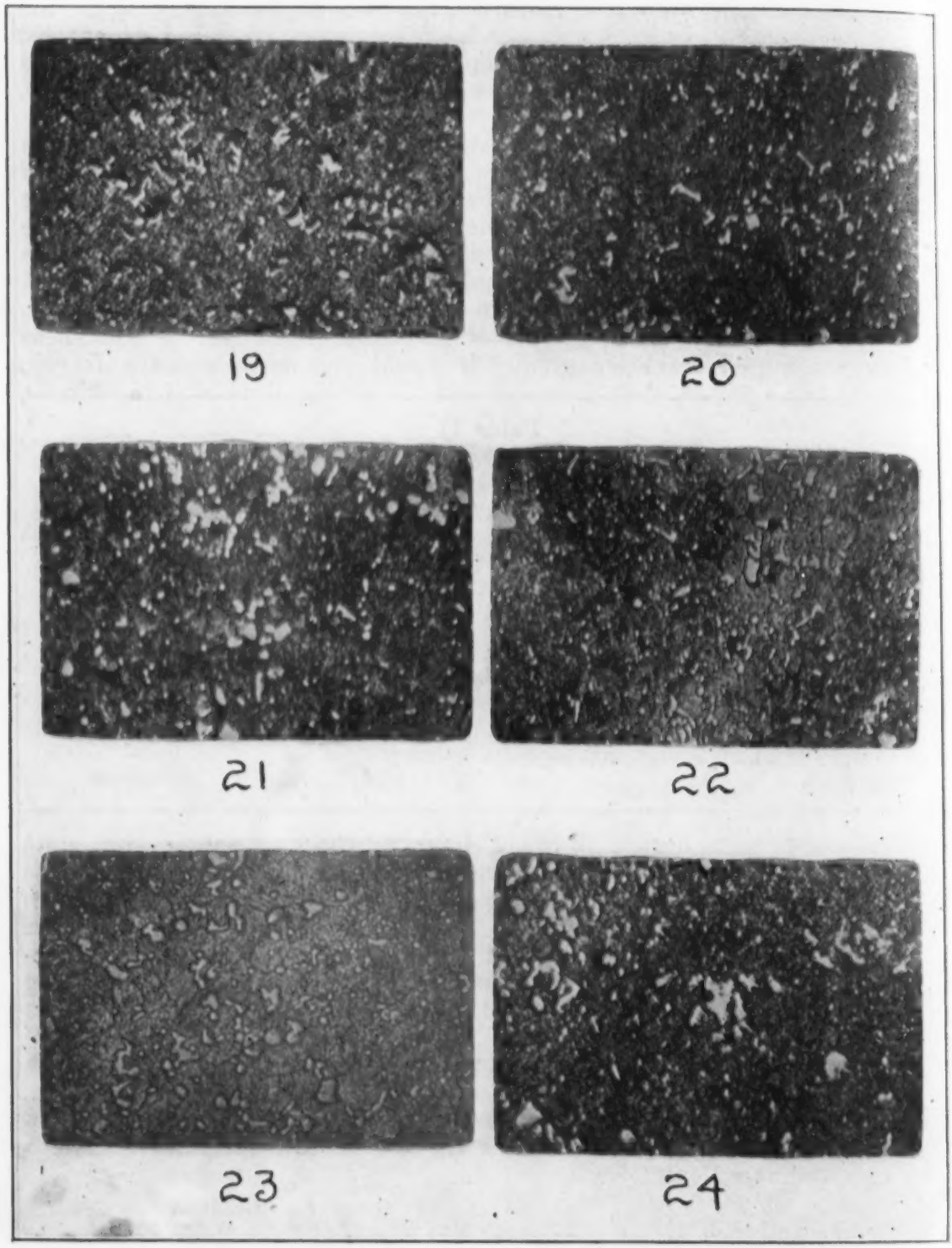
1460 degrees Fahr. brine quench, 400 degrees Fahr. draw	Room temperature	183,000
1460 degrees Fahr. brine quench, 400 degrees Fahr. draw	1100	65,000

of steel requires a higher drawing temperature to produce the same changes in microstructure than is required by the *A* grade. It is also interesting to note the extremely low fiber stress on the *B* grade drawn to 450 degrees Fahr., in comparison with the *A* grade given the same heat treatment. Micrographs of both grades of steel, drawn to 1100 degrees Fahr. show a complete disappearance of the polyhedral structure of austenite, and the development of a full martensitic structure. This structure is the most desirable one, for material possessing this microstructure has the greatest strength, proper hardness, and greatest degree of red hardness.

One and three-sixteenths inch diameter hot rolled and annealed bars of high speed steel were obtained for the tensile test specimens. These bars analyzed as follows:

	Grade *A*	Grade *B*
Carbon	0.65	0.69
Chromium	3.62	3.13
Vanadium	0.95	1.68
Tungsten	17.80	13.96

The test specimens were made with shoulders instead of threaded ends, for past experience has shown that it is impossible to obtain accurate tensile test results on hardened high speed steel with the standard U. S. threaded end test pieces, due to the specimens usually failing in the threads.



Figs. 19-24—Micrographs of grade *A* tensile test series. Etched 3 minutes in 5 per cent nital and X 465. Fig. 19.—Cross section, 2350 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr., tested at room temperature. Fig. 20—Cross section, 2350 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr., tested at 600 degrees Fahr. Fig. 21—Cross section, 2350 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr., tested at 1200 degrees Fahr. Fig. 22—Cross section, 2350 degrees Fahr. oil quenched, drawn to 450 degrees Fahr., tested at room temperature. Fig. 23—Cross section, 2350 degrees Fahr. oil quenched, not drawn, tested at 800 degrees Fahr. Fig. 24—Cross section, 2350 degrees Fahr. oil quenched, not drawn, tested at 1100 degrees Fahr.

A large number of these specimens were to be tested at elevated temperatures, so the test specimens were made 11 inches in length in order to allow a sufficient length on each end of the test specimen to extend through the electric heater so as to fit into the specially designed holders. The electric heater, shown in Fig. 31, is quite similar in design to that used by Mr. MacPherran.[1]

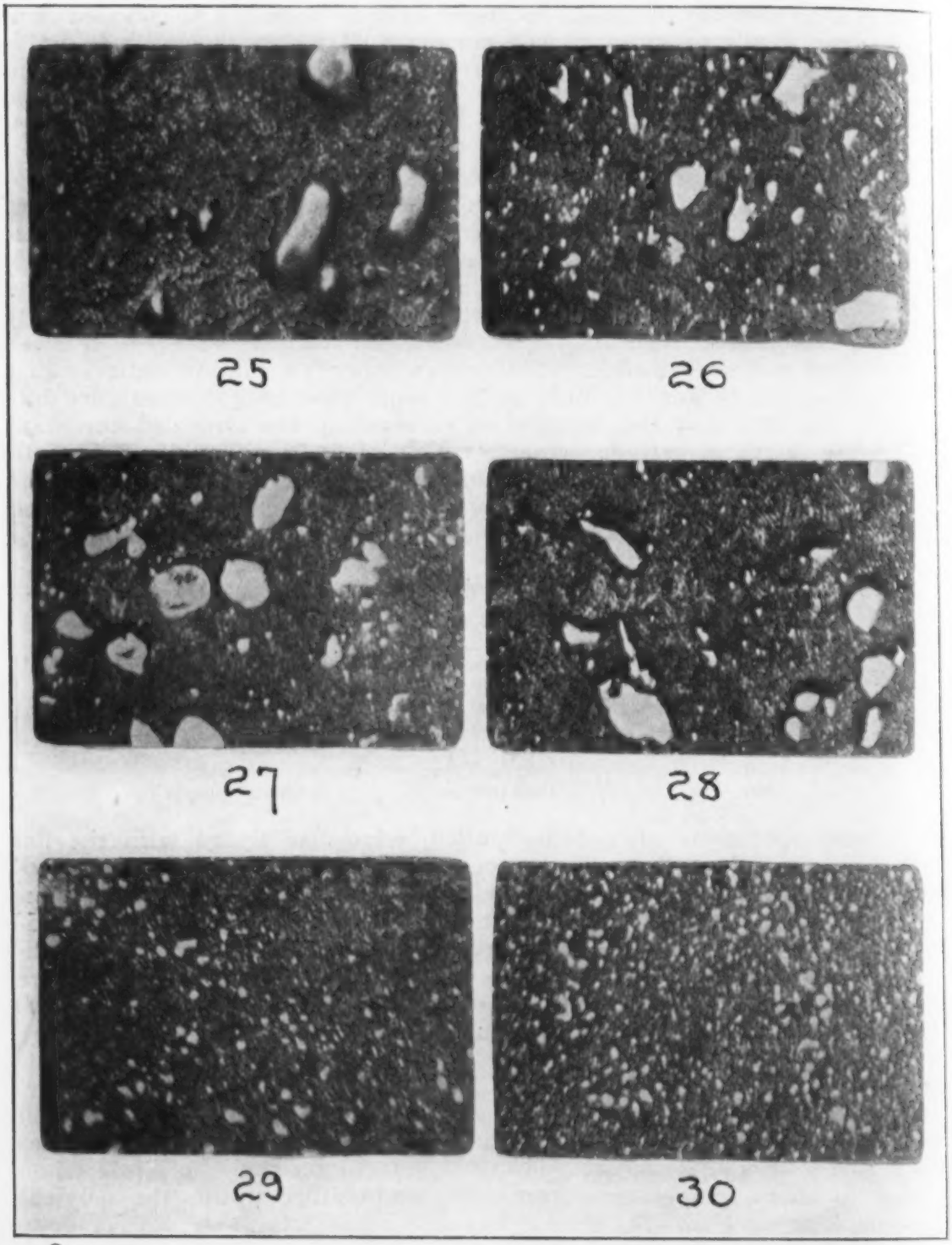
Fig. 32 shows the heater in position on the Tinius Olsen universal testing machine. All specimens were held at temperature for 30 minutes before being tested. The results obtained with the various heat treatments, and at the different temperatures tested, are shown in Fig. 33. Additional tensile tests are shown in Table II. The fractures of the grade *A* specimens pulled at room temperature all had the usual velvety appearance, but the fractures of the specimens made from grade *B* steel, all showed a coarse, fairly crystalline structure. The author believes that this coarseness is due not only to the high quenching temperature but also to the fact that the material as received in the annealed condition had large lumps of carbide present, which, of course, would not go into solution upon hardening, as shown in Figs. 18-24. The fractures on the specimens tested at temperatures higher than room temperature presented an interesting range of colors as is shown in the following chart:

Temperature at which specimen was tested degrees Fahr.	Fracture Colors	
	Grade *A* Steel	Grade *B* Steel
Room temperature	Steel gray	Steel gray
400	Steel gray	Steel gray
600	Very dark gray	Very dark gray
800	Chocolate brown	Medium brown
1000	Dark blue	Dark blue
1100	Greenish blue	Greenish blue
1200	Dull purple	Brownish purple

These specimens after being pulled, were also tested with the flat temper testing files, all of these pieces being hard to file with the exception of the grade *A* and *B* specimens tested at 1200 degrees Fahr., these being filed with difficulty, and the grade *A* specimens quenched from 2350 degrees Fahr., not drawn, and tested at 800 degrees Fahr. The specimens which were drawn to 1100 degrees Fahr. before being tested were file hard after each temperature tested from room temperature to 1100 degrees Fahr. This illustrates another advantage of the high drawing treatment, for tools in service which have not been drawn quite often attain a temperature of 600 to 1000 degrees Fahr. These tools, therefore, will be very soft, after being cooled to room temperature in comparison with their original hardness, whereas tools drawn to 1100-1150 degrees Fahr. before being placed into service will maintain their hardness when cooled to room temperature from any temperature up to the original drawing heat.

Micrographs were taken from some of these tensile test specimens and are shown in Figs. 18-30. As stated in a previous part of this article, the microstructure of the grade *B* steel was in a very unfavorable condition as received, due to the presence of large carbide lumps. The structure on the grade *A* material as received, is satisfactory. Specimens drawn to 1100 degrees Fahr. after quenching show the same microstructure after

1 "Comparative Tests of Steel at High Temperatures," by R. S. MacPherran, A. S. T. M. Proceedings, 1921.



Figs. 25-30—Micrographs of grade *B* tensile test series. Etched 3 minutes in 5 per cent nital and X 465. **Fig. 25**—Longitudinal section, annealed condition. **Fig. 26**—Cross section, 2350 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr., tested at room temperature. **Fig. 27**—Cross section, 2350 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr., tested at 600 degrees Fahr. **Fig. 28**—Cross section, 2350 degrees Fahr. oil quenched, drawn to 1100 degrees Fahr., tested at 1200 degrees Fahr. **Fig. 29**—Cross section, carbon tool steel. 1440 degrees Fahr. brine quenched, drawn to 400 degrees Fahr., tested at room temperature. **Fig. 30**—Cross section, carbon tool steel. 1440 degrees Fahr. brine quenched, drawn to 400 degrees Fahr., tested at 1100 degrees Fahr.

every temperature at which the specimen was tested. This is to be expected, for a temperature higher than the original drawing temperature must be exceeded before the martensitic matrix is changed into troostite.

Micrographs of the samples of carbon tool steel tested at room temperature and 1100 degrees Fahr. are also shown in Figs. 25-30. The sample tested at room temperature shows a martensitic matrix with free cementite present, while the samples tested at 1100 degrees Fahr. show a sorbitic matrix with a large amount of free cementite present.

Referring again to Fig. 33, we note that both grades of steel attain their maximum tensile strength at 600 degrees Fahr. Hardened high speed steel, therefore, gives the same characteristic curves when tested at elevated temperatures, as do plain carbon and alloy steels. The grade *B* specimens gave lower reading than the type *A* samples, as would be expected from an examination of the fractures. The author believes that drawing specimens of both grades of steel to 1150-1175 degrees Fahr. would have produced higher tensile strengths, without sacrificing the hardness to any extent.

Grade *A* test specimens quenched from 2350 degrees Fahr. and not drawn showed a tensile strength of only 175,000 pounds to the square inch, about 70 per cent of the value obtained in specimens quenched from 2350 degrees Fahr. and drawn to 1100 degrees Fahr. Specimens drawn to 450 degrees Fahr. after being quenched from the high temperatures, showed a tensile strength of 185,000 pounds to the square inch. Very little increase in strength, therefore, is obtained by drawing to only 450 degrees Fahr. Carbon tool steel, given its usual heat treatment, gave a tensile strength of 183,500 pounds to the square inch, tested at room temperature, and 65,000 pounds to the square inch when tested at 1100 degrees Fahr. Carbon tool steel shows a higher tensile strength at room temperature than high speed steel quenched from 2350 degrees Fahr. and not drawn.

All of the high speed test specimens were measured for elongation and reduction of area and none was obtained, even on samples pulled at the high temperatures. Hardened high speed steel, therefore, possesses zero ductility, even when tested at a red heat.

The following precautions were taken in conducting these tests: (1) The specimens were all timer hardened, so as to insure the heat treatment being a constant; (2) All pyrometers were carefully calibrated before being used; (3) The accuracy of the testing machine was determined.

The writer does not wish to convey the impression that the physical strength of high speed steel is an indication of its cutting qualities, but does believe that tools possessing the proper analysis, hardness, and red hardness, together with the highest possible physical strength, will give the most satisfactory service.

Discussion of Mr. d'Arcambal's Paper

CHAIRMAN FOLEY: Mr. D'Arcambal seemed to find it is very difficult to get respective hardness tests on high speed steel that mean anything. I suppose that is the general experience in testing high speed steel. After all, the real test of that is in the eating of the pudding.

DR. JOHNSON: I would like to ask just with regard to carry-

ing those drawings higher, whether you expect then, no doubt, to get some elongation or reduction in your high speed steel. Did you carry them higher to see what elongation and reduction you could have gotten in high speed steel? This is interesting to me from the fact that we have some such line of work in mind, but have not gotten to it as yet. Suppose you had drawn your tests to 1300 and 1400 degrees Fahr., what then?

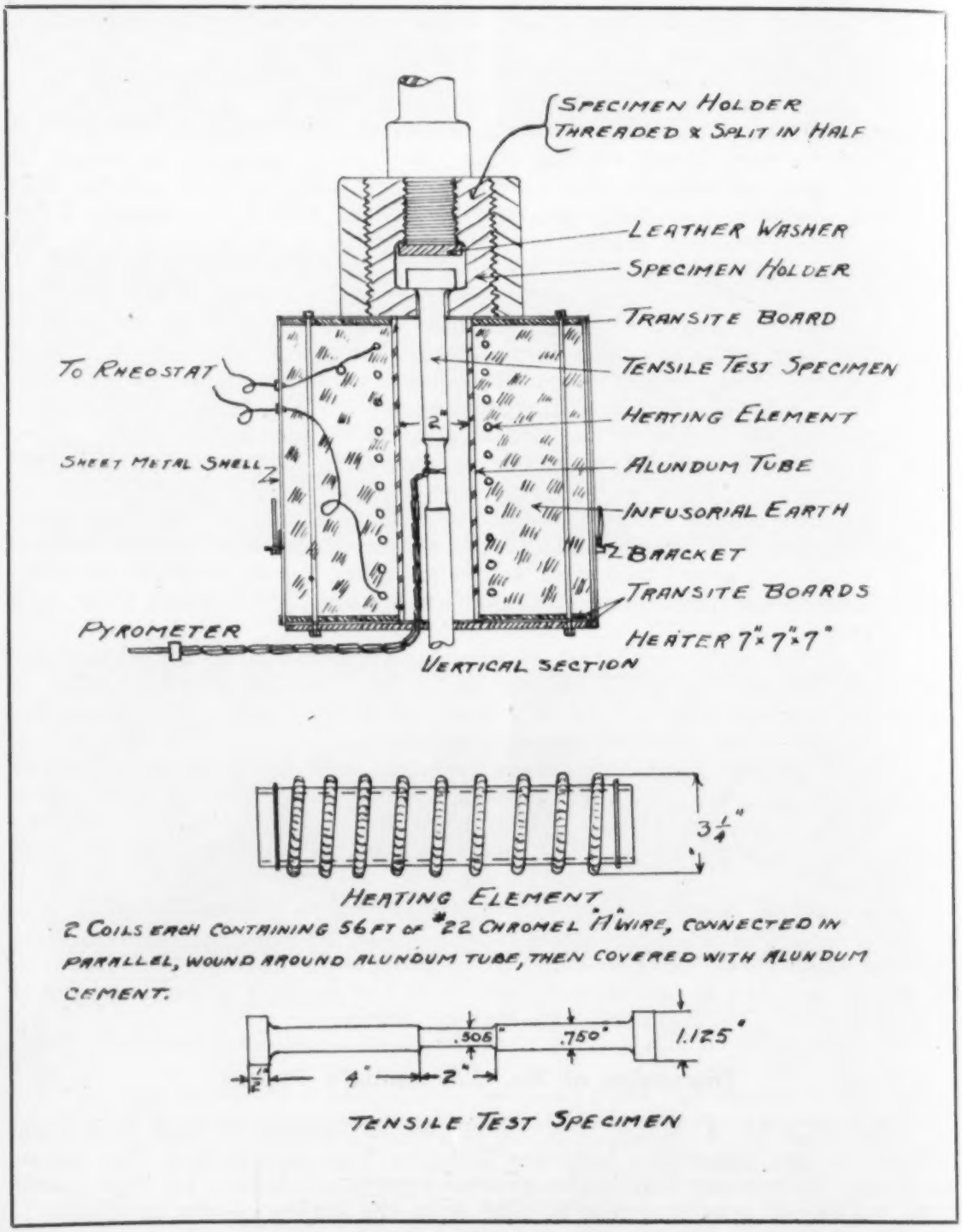


Fig. 31—Cross sectional view of electric heater and test specimen

MR. D'ARCAMBAL: We tested up to 1200 degrees Fahr. only, as we had made up only enough test specimens to cover that range, never expecting to obtain such results as to elongation and reduction. We really expected to obtain some ductility from 1000 degrees Fahr. and higher. Time did not permit of our making and breaking more specimens, but we will try to do so, as I am interested also in seeing just where you do get ductility in hardened high speed steel. I really think if we would have drawn those specimens to 1150 or 1175 degrees Fahr. before testing, we would have obtained higher results on tensile strength. Don't you believe so?

DR. JOHNSON: Possibly so. But those drawing propositions do not, as you know. In some of the higher draws you get results that you don't expect.

MR. D'ARCAMBAL: One thing I omitted stating was regarding the fracture colors. It was interesting to note the colors obtained on the fractures after the specimens were taken from the heater. Testing at room temperature, we obtained the ordinary steel gray, at 400 degrees Fahr. the fractures were still of a steel gray color, testing at 600 degrees Fahr. the fractures were of quite a dark gray, but still there was no noticeable color in the fracture. Testing at 800 degrees Fahr., the fracture on the 18 per cent tungsten steel was chocolate brown color, and the 14 per cent tungsten, 2 per cent vanadium steel the fracture was a medium brown color. Testing at 1000 degrees Fahr., the fracture on the 18 per cent tungsten steel was a dark blue, the same color as we obtained on the 14 per cent tungsten steel. Testing at 1100 degrees Fahr. the fracture on the 18 per cent tungsten was a greenish blue, and the same color obtained on the 14 per cent tungsten. Testing at 1200 degrees Fahr., the color of the fracture on the 18 per cent tungsten was a dull purple, and on the 14 per cent tungsten steel a brownish purple. But I don't believe those colors mean very much, because we found that they depended a lot on the time we left the specimens in the heater after they failed. Unless we removed the specimens immediately, the colors varied.

CHAIRMAN FOLEY: How long did you hold those in the drawing temperature at 1100 degrees Fahr. when you drew them to 450 degrees Fahr., that is where you heat treated the specimens?

MR. D'ARCAMBAL: They were first placed in the oil and brought up to around 500 degrees Fahr., which required, we will say, 35 minutes, then placed in the lead bath at around 700 degrees Fahr. and brought up to 1100 degrees Fahr. and then held there for 15 minutes. One mistake that has been made on the drawing of high speed steel, is to just bring the work up to 1100 degrees Fahr., or whatever it is drawn to, and then to take it out. We have taken high speed steel and quenched it in oil and then drawn to 1100 degrees Fahr. holding there for an hour, and it is absolutely file hard. In other words, you cannot over-draw like you can other types of steel. In pulling the test pieces, it would usually take around half an hour for the pyrometer and the piece to come to temperature. We allowed the specimen to remain at that temperature another half hour and then tested the same. The thermocouple was attached to the specimen, the asbestos cord breaking, as well as some of the porcelain insulators when the specimens failed. Before running these tests we had our

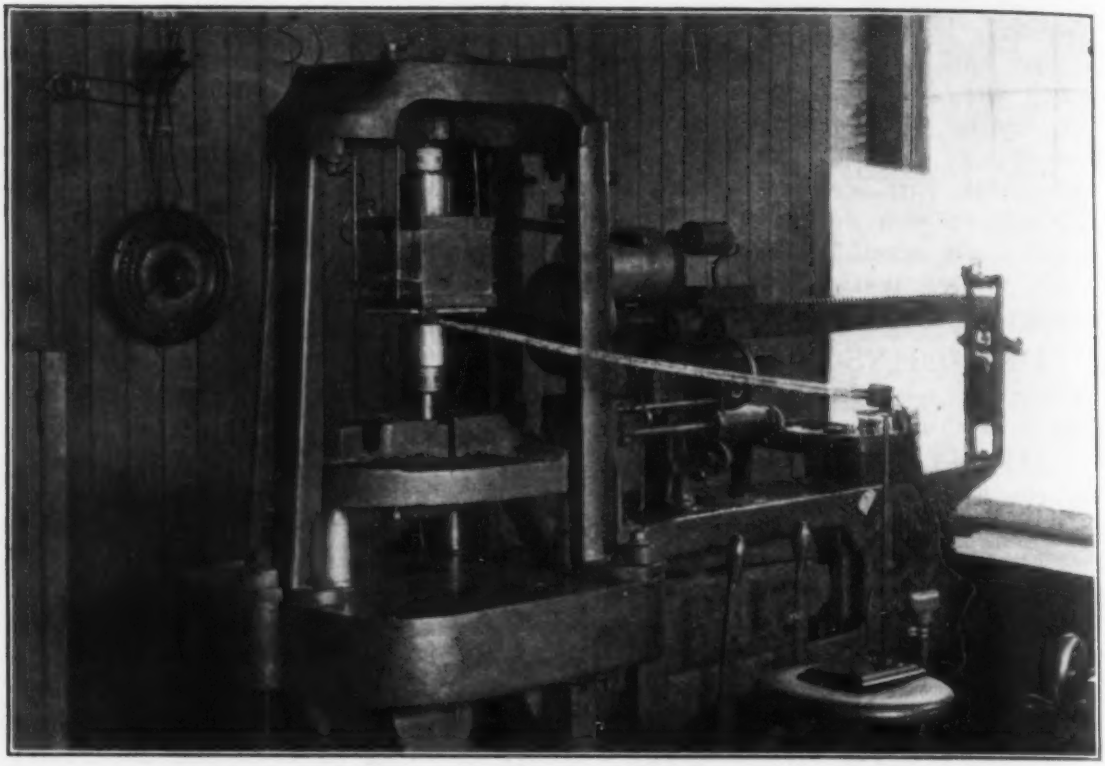


Fig. 32—Electric heater shown in position on testing machine

tensile machine standardized, and we checked all our thermocouples in order to insure the results being accurate.

MR. CROWE: I would like to ask Mr. D'Arcambal if there seems to be any relation between the physical properties in the performance of tools made from steel? Can you pick out steel that has good physical properties?

MR. D'ARCAMBAL: I never tried to do that. I don't want to try to convey the impression that you can pick out a good high speed steel by its strength, that is, a high speed steel having the highest physical strength will make the best cutting tool, but I do believe that high speed tools having the proper analysis, hardness and red hardness, together with the highest possible physical strength, will do the most work. In other words, you can take a high speed steel tool with the proper analysis, quench it and probably give it a long draw. It hasn't the highest possible physical strength, and I believe for that reason on tools drawn to 1100 degrees Fahr. you will obtain greater production because you get greater strength than with the low draw, obtaining therefore, greater life with the high draw.

MR. WEED: I would like to ask Mr. D'Arcambal if he thinks the treatment at 1100 degrees Fahr. draw should be used for all high speed tools, and do away with lower draws.

MR. D'ARCAMBAL: I think so, yes. I have heard some people state that they have tried the high draw and it doesn't work on all kinds of cutting, but I see no reason why it should not. In other words, it insures you of obtaining the proper quenching temperature, for you can take a tool and quench it from 2100 degrees Fahr. and it is file hard without drawing, but a quenching temperature of from

2300 to 2350 degrees Fahr. is necessary to obtain the proper hardness after the high draw. Your high draw will also give you greater stability. One way to prove that is to take a specimen and quench it and then draw to different temperatures and you obtain the characteristic scleroscope or Brinell curve. It will go straight, then down, and at 1000 degrees Fahr. you start coming up again. You take the specimen again, after it has had the 1100 degree Fahr. draw, and draw it again through those temperatures, and you have a straight line, about 92 scleroscope all the way through. The high draw on any tool will give you the greatest possible physical strength and also thermal stability. I cannot imagine any tool, where the high draw will not be beneficial, unless it is a special type of tool that wants to be soft. In that case, possibly it is better to draw to 500 degrees Fahr. Of course, you take some form cutters, threaded tools, etc., and it is a mighty hard proposition to quench from 2300 degrees Fahr. and not spoil your tool on account of excessive scaling. So a lot of people pack harden form cutters and say they obtain wonderful results. The reason for that is that the usual type of form cutters are run at low speeds, probably the regular carbon steel speeds.

MR. GROSSMAN: I would like to ask Mr. D'Arcambal what the concordance of the transverse tests were?

MR. D'ARCAMBAL: Transverse tests checked quite closely. I would say both the transverse and tensile tests checked within 2 to 4 per cent, possibly around 2 per cent. On the transverse tests, some

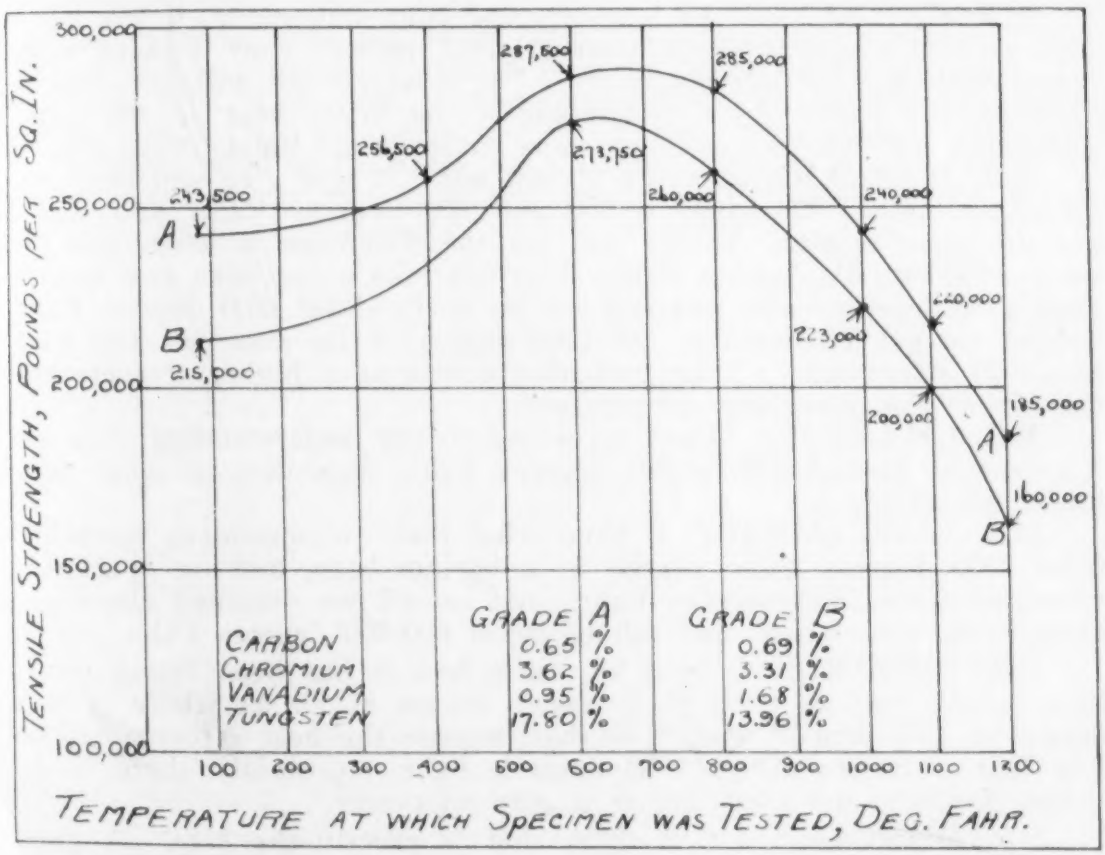


Fig. 33—Tensile test curves. All of the specimens were quenched in oil from 2350 degrees Fahr. and drawn to 1100 degrees Fahr. before being tested

samples we ran in triplicate. On the tensile tests we only run them in duplicate. I was a little afraid at first that the results wouldn't check very closely, but was quite surprised to note how closely they did check. I think one reason for that is that the specimens in each case were all made from the same bar of steel. That insured the same chemical composition and manufacturing conditions. They were all machined at the same time, kept in the high temperature furnace the same length of time, quenched in the same way and all drawn at the same time. I think for that reason the results agreed fairly accurately.

MR. GILLETTE: I would like to ask a question with regard to that curve. In drawing you state that the first drawnig that you get a drop in your curve and then if you draw the same specimen again that you get a straight line. Is that always proved true?

MR. D'ARCAMBAL: I have checked that about four times with different specimens, and have obtained the same results. Quenching and not drawing you obtain a scleroscope of about 92. Drawing to 600 degrees Fahr., it goes down to 86 or 87; at 800 or 900 degrees Fahr. it remains about the same. Say you did have a 93 at 1100 degrees Fahr. draw, you start over again and draw and you get 93 at each drawing temperature, obtaining a straight line the second time. The file also verifies that.

MR. GILLETTE: What would be the result if you requenched that? Would it go through the same line and would the curves compare?

MR. D'ARCAMBAL: What temperature?

MR. GILLETTE: As I understand your statements, if you get a high enough temperature for your original quench, your drawing operations will show a different curve. For instance, we will say 2300 or 2250 degrees Fahr. As I understand it the lower heat on the initial quenching will not give you the same curve as the higher heat will.

MR. D'ARCAMBAL: No, it will not. It will give you the same initial hardness. Drawing to 600 and 800 degrees Fahr. you would get the same results. Where you get the difference is when you get up to 1050 or 1100 degrees Fahr. You can take a specimen you quench from 2350 degrees Fahr. and you can go up to about 1200 degrees Fahr. before you get a softening. At 1200 degrees Fahr. you will still have about 93 scleroscope. Your softening comes at a higher temperature, the higher the quenching temperature.

MR. GILLETTE: Then according to my understanding, you get the drop at around 600 or 700 degrees Fahr. regardless of what your initial quenching is.

MR. D'ARCAMBAL: I have tried that on specimens quenched from 2100 degrees Fahr. heated in a barium bath, and on specimens quenched from 2300 degrees Fahr., and on all we obtained about the same initial scleroscope, and falling off at 600-800 degrees Fahr.

MR. EDWARDS: On a big lathe tool it has been found sometimes to be just as good if it wasn't drawn at all as where it was drawn to 1100 degrees Fahr. Is that because the heat is generated so fast that it comes up to 1100 degrees Fahr. so rapidly there is no chance for it to get away before it gets up there?

MR. D'ARCAMBAL: I think that is exactly the case. A good many lathe tools run continuously at a dull red heat. Professor Arnold in England tested some hardened but undrawn lathe tools and dis-

covered that always on the first re-grind they ran better. The fact is that on the first running he drew them. Then on the second trial he got better results. Try to get a blacksmith to draw a high speed tool to 1100 degrees Fahr. and he would think you had had a drink of "hooch."

QUESTION: If you had a point of 350 degrees Fahr. and then drawing up to 500 degrees, and then running up to 1100 or 1150 degrees and leaving your tool in the lead, letting it freeze there, then bringing it back, after it is perfectly cold to the 1100 degrees of heat again, what would be the result?

MR. D'ARCAMBAL: The same result as though you took it out of the lead; it would be the same thing as running it in practice afterwards and getting it heated up, then cooling off.

DR. JOHNSON: I notice the speaker quotes scleroscope readings there along with the different drawings with a percentage of accuracy. Now what percentage of accuracy does he think he got in the scleroscope readings?

MR. D'ARCAMBAL: In order to obtain the greatest accuracy on scleroscope testing, we had specimens surface ground after hardening, taking about 0.020 inch off of each face. Then we scleroscoped each of the ground surfaces, about 10 readings on each face, making 20 readings on the piece, and then averaged them, and you have some variation, even at that. You take the test blocks that the instrument company furnishes, supposed to read 103, you put it on the base of the machine and read it and it is 103, put a very thin piece of paper on it under the block and you get about 90. If you don't have absolutely parallel surfaces it is not worth anything. That is the reason I don't believe the scleroscope or Brinell is worth much on testing tools.

MR. NELSON: Mr. D'Arcambal referred to experiments carried on in England by Professor Arnold. I have been present at quite a lot of those tests of Professor Arnold and I think it is only fair to Mr. D'Arcambal to say that those tests made by Professor Arnold support his own paper as given here.

THE PRESENT SITUATION FROM A BUSINESS STANDPOINT

By Richard Spillane

I CANNOT indulge in technical language; I speak only ordinary United States. In fact, my province is not speaking, I just do a bit of word carpentry in the written form, but I have pronounced ideas about various subjects and one of them is that we have not looked at some of the influences of our present development. I believe we might have had aggravated trouble a little later, if it had not been for the war. We have had in the last 100 or 150 years the greatest revolutions in the history of the world. We know our historical resumes place Alexander, Caesar, Charlemagne, Napoleon and probably the Kaiser as the great revolutionists of the world. They were really pikers; the real revolutionists of the world have been Watt, Stevenson, Hargreaves, Eli Whitney, Morse, Edison and Marconi. These men changed this world of ours from a dreary to an industrial world. They wrought greater changes in the last 150 years than in all the preceding ages. Those of you who have read know that before the age of steam, the work shop or factory, whatever you wish to call it, was in the home. They did not have a distributing agency. It was not until they began to manufacture cotton goods with the loom and spindle, that there was a necessity for a real distributing system and we do not pay attention today, do not recognize today the wonderful changes that have come to us.

A talk that was printed this morning shows a resume from a revision by Mr. MacFarlane in Commercial America. In 1921, imports of machinery into India had a value of $68,000,000. This was more than twice the value of all the machinery exports of Great Britain and the United States in 1870.

In 1920, imports of machinery into China were $29,802,000, or nearly as much as the total machinery exports of Great Britain and the United States to all countries in 1870. The tremendous industrial development throughout the world in the last 50 years, the change from agrarianism to industrialism, explains to a large degree how the world war dislocated every geographical division. Dependence upon machine power has greatly increased the interdependence of nations.

Up to 1870 Great Britain virtually dominated the machine market; in that year her exports of machinery were $25,000,000, and those of the United States $5,000,000. In 1920 the exports of the United Kingdom had reached $308,000,000, or 12 times those of 1870, while those of the United States had vaulted up to $536,000,000, or 107 times greater than in 1870. Today the total machinery exports of the principal nations aggregate more than a billion dollars with the United States commanding more than one-half of the total and apparently being destined to increase her leadership. I may tell you the exports of sewing machines alone from the United States in one year now are three times greater than all of our machinery exports in 1870; exports of typewriters are five times as great as all of our machinery exports in 1870. The same thing is true in relation to adding machines, so when you come to automobiles, you have to express it in very fine terms.

The war you may trace, in part, to the impetuosity of the Germans.

A paper presented before the Philadelphia Chapter. The author, Richard Spillane, is editor business section, *Philadelphia Public Ledger*.

They wanted to get to the front at a quicker pace than they would otherwise reach that goal. What I would like to point out is this, that with this tremendous change in 50 years for the drawing together of the world, what can we expect in exports 25 or 50 years hence? If you can make such an advance in infancy, what can you expect as you approach maturity?

With this tremendous revolution, we have brought about various troubles. We have gone into production in this country on the most gigantic scale ever known and we have arranged all of our methods of production for the maximum production and while we have been doing so, we have paid little attention to another cog in the whole machine—that of distribution. Today we are between the devil and the deep blue sea with the tremendous costs of our distribution. If you take $10.00 as a unit of cost for a product of the General Electric Co., this being amount paid by the consumer, the amount received by the General Electric Co. for that product would be $2.59. These are not my figures, but figures obtained from the General Electric Co. I would like to know why for what they sell for $2.59, the consumer should pay $10.00?

I give as another illustration the soda cracker. When I was a youth, I went to the grocery store and I used to have a free lunch. I could go to the soda cracker barrel and get as many as my stomach would hold or that my appetite would crave and soda crackers in those days cost 5 cents per pound. It was not a very sanitary way for everybody went to the barrel and some people were not as sanitary as possible. I live out in the country now and a short time ago my wife requested me to bring home some saltines. Saltines, as I know them, are soda crackers with a little salt on them. I bought a box of saltines all put up in a nice box, neatly and sanitarily packed in an attractive container. I paid 18 cents for the container of saltines. I put them on the scale, resulting in the information that a pound of soda crackers, at the price I paid for these saltines, would today be 78 cents. If anybody on earth can justify an increase from 5 to 78 cents for soda crackers, just on account of their being put up in a little bit more sanitary method and in a more attractive container, I cannot see it.

You have the same thing in many different forms in this country. I was present at a banquet at the Bellevue Stratford one night recently and they had present some of the most eminent bankers of this district, also eminent engineers. The bankers confessed they were up a tree in many ways. They said this matter of distribution was hog-tying the industry of the country, and the engineer was greatly responsible—he was a person with an undetached mind. Some of their statements were that the engineer had been responsible for the development of the machine and it was now up to him to work out this problem of distribution. I think they are right. The engineer has an undetached mind. We have to settle this cost of distribution. It is one of the most horrible wastes we have in this country. It is in every field and every form. Take for example the matter of your own steel industry. I sat alongside of Charles M. Schwab the other night and after the regular speakers, the crowd called for Mr. Schwab. After telling a few pleasant stories, Mr. Schwab made a remark that at Bethlehem they were not making any money; that they had to sell steel at less than cost, also that the cost of the five elements necessary to the making of steel, plus the freight rate was more today than the price they got for steel, but

that really one of the largest costs was transportation. He asked some of the railroad executives who were present, to take that home with them.

It is one of the problems. You can recall when we rode around this country for 2 cents a mile—you cannot do that today. I rode about 8000 miles recently and I got a little information on the road and more jolts, principally down in the southwest. I will never forget the trip from New Orleans to Dallas—I thought I was going through the roof of the sleeper at times. Some of the prices I had to pay for transportation put an awful kink in my bank roll. The railroads do not seem to be making money. They have to pay a large amount of money for things they have to purchase. They cannot rehabilitate themselves. They have need for steel to a degree they never knew before; needs for lumber; needs for everything. One of the railroad presidents that I interviewed on my trip, almost wept on my shoulder, telling me the sad experiences he had to undergo. One thing was that the month previous he did not know whether he was going to be able to meet his payroll and had drawn on the banks to the limit. Somehow he bridged the situation.

I also met a number of steel people. I met the executives of the United States Steel Corp.; the Colorado Fuel & Iron Co.; and Tennessee Coal, Iron & Railroad Co. From some of them I got remarkable statements. Mr. Crawford, of the Tennessee Coal, Iron & Railroad Co., told me that he had offered to supply the rails urgently needed by one of the railroads of the South and the president of the road declined his offer to furnish the steel and wait for payment, because he had to reduce his maintenance of way force to such a degree that he did not have sufficient men to take out the old rails and put in the new. That condition is, to a great extent, applicable to every part of the country. They should place orders now, but the railroads, from reports of railroad presidents made to me, never were in such urgent need of refurnishing, particularly as to steel.

I do not know whether you gentlemen will coincide with my views. I do not think that Europe, for instance, is in so bad a condition of financial bankruptcy, as she is in bankruptcy of brains. We are going to have some of the governments abroad, some of the nations abroad go bankrupt—the quicker they do so, the better for them and the better for the world. Bankruptcy of a nation is not what bankruptcy is to a business concern. You cannot take from a nation the real assets; you cannot take from it the earth and human power; you cannot take from it the growth of crops, for men will work when it comes down to live or die.

We have had some practical knowledge of the debasement of money. You get debasement of money abroad to a degree that is appalling, but you know we are a thoughtless lot. We do not look back to the debasement of the currency of the United States. We do not remember that we had some horrible situation to meet in these United States and we do not appreciate how stupid we have been ourselves at times.

One of the noblest works of men, to my mind, is the constitution of the United States. Some eminent foreigners have told us there is nothing that has come from the pen of man, in the last 18 to 20 centuries comparable to it. It took the leading men of the United States about six months to agree upon the framing of the constitution and it took more than six months after it was framed for the people of the United States

to accept it. In the great state of New York they held a convention at Poughkeepsie; De Witt Clinton led one faction, Alexander Hamilton the other. De Witt Clinton and his following had about three-fourths of the convention—Mr. Hamilton but a very small part. It was not until after the required number of states had accepted the constitution that New York accepted the document which is now the constitution of the United States. During that time, the dollar that we know today, was debased to the point, where it had the purchasing power of only 2 cents. Our whole commerce was at a standstill. There were very few ships on the sea with the American flag; we had no industry, no business. We were about in the condition that parts of Russia are in today. We do not remember these things, but as soon as we got started, we got back in a short time.

We have had bankruptcy of nations in various parts of the world; there have been several occurrences in South America; Argentine went bankrupt twice; France did some crazy things in finance. Then we have Poland before us now. Mr. Vanderlip says that when he was in Warsaw a few months ago, he stopped on the street to look at a woman selling newspapers. She had by her side a pile of newspapers unsold (we do not blame anybody for not buying a Polish newspaper). Alongside of the newspapers she had a stack of paper money and the stack of paper money was almost as large as the stack of newspapers and of almost the same value. He also tells of when in Vienna, he hired a taxicab and rode about that beautiful city for an hour or so. When he came to pay his score, he paid the meter price 60 times over and found when he translated the money into gold equivalent, it would have been cheaper for him to keep the cab all day than to hire another. In Berlin he rode about for a considerable time in a taxi and that time paid the taxi only six times the registered fee and in gold equivalent he had paid out 4 cents. The sooner they get rid of this paper blockade in Europe the better. They have got to get rid of a lot of other things. One thing they must get rid of is their passion for hate; they have also got to get rid of their present method of hitting at each other's geographical lines.

Senator Hitchcock, of Nebraska, wants to establish a Bank of Nations, a Federal Reserve of Nations. Of course, the United States is to hold the bank; capital to be $2,400,000,000. Mr. Vanderlip has a little different scheme. Senator Hitchcock was for the United States to control this money. Some of our friends, particularly the British, who have a genius for finance, would not quite agree with this proposition. Mr. Vanderlip has another idea, he would also have a Federal Reserve Bank of United States of Europe and it would be for us to put up the money holding on to it until they got out of their quagmire abroad, then they would resume control and we would gracefully retire. He also thinks that Europe ought to pay the debt it owes to us. We are all strong for that. Mr. Vanderlip does not think that it ought to be paid now, in 10 years or 25 years, but that they ought to pay that money to us and we should hold on to it for about two and one-half minutes, then we should employ it to the great work necessary abroad for the transportation system, etc., particularly the hydroelectric development. He believes there would be a very good profit in 25 years, or more, then Europe could repay that money.

To get down to the real matter, the whole question of the world is individual. It is a matter of work. We all have to work a little harder —we all have to make a bit better return for what we get. We have

done some crazy things every way; we have done a lot of them for which we should be ashamed. We are not justified in many instances to criticize the people of Europe as we do. We have not had the struggle they have had. We have to be generous; we have to be considerate. We have to abate some of the desires for the repayment of the loans we have made abroad. I think that we have assurety of a quicker return to normal conditions in Europe than appears on the surface today. I have great faith in the wish of man to live. When men have to work to live they will get down to brass tacks.

I have great faith when I read about the development of the other continents; when you think of what Asia has to develop. In the next 50 years, they will astound the world; their resources are beyond belief. There is more coal in China than in the United States and we have a lot of it here. The State of Colorado has equally as much as this wonderful land of Pennsylvania and I think Utah has more than there is in Colorado. China has more iron ore than we have. She has illimitable resources, if we are to believe the records of the geological survey people. We are getting down to the beginning of real industry in the Far East. We know nothing of the real worth of Africa; the copper deposits of Africa are immeasurable; these are about 2000 miles inland and until that country is opened up, no one knows what the developments will be in that section as well as South Africa.

The same is true with South America. I have talked with Mr. Braden, one of the greatest copper men in the world. He now controls in Southern Bolivia, in South Argentine and West Argentine, the foot hills of the Andes, 25 million acres of land that the geological people declare is very profuse with oil. They declare that the largest oil field that the world knows is in Southern Bolivia. I have read reports of 28 different surveys made by men eminent in the field of oil and they all report very fine oil territory in the Andes. The same way in North and South Argentine, Venezuela, Colombia, and Northern Brazil.

With the opening up of the South American oil fields, as they will be opened up, I may tell you that the Braden proposition is for the deepening of various rivers leading into the territory of Southern Bolivia. We should procure a passage for ocean steamers to go about 1200 miles up from Buenos Ayres. This will be a wonderful revision in transportation in the Southern Seas. There will be a development in the south comparable to something like the north and with all this, what is it going to do for your line. If the exports of machinery today amount to one billion dollars and it sprang from 30 to 35 million in 1870, what can you expect in 1970—50 years hence, 25 years hence? I think any man can make a guess and it may seem wild, yet it may be reasonable. This world we look upon is fairly well developed, but it is only in its swaddling clothes. This development is due to the industrial leader today who is the steel man. If he is not, I would like to know who is.

DOWMETAL AND ITS APPLICATIONS

By J. A. Gann

METALLIC magnesium is the lightest known metal that can be classed as an engineering material, and it has only recently received this distinction. This metal has been used in the past chiefly as a deoxidizer, for photographic flashlights, for pyrotechnics and explosives, and in alloys where small amounts are often desirable. The annual consumption for all these purposes prior to the war probably did not exceed 35,000 to 40,000 pounds and almost the entire supply came from Germany. When importations were cut off in 1915, large scale domestic production of magnesium was started in order to meet the demand for military purposes, and by 1918 the estimated output reached 400,000 pounds. This industry proved to be chiefly a war-baby as evidenced by the fact that in 1919 production in most plants practically had ceased. In anticipation of such a condition, the Dow Chemical Co., Midland, Mich., started investigations as far back as 1916, the object being to develop a metal adapted to peacetime industries. The series of magnesium alloys commercially known as dowmetal is the result.

The Dow Chemical Co. is situated advantageously as far as the magnesium industry is concerned. The main source of raw material for its various plants is a brine pumped from a depth of 1200 to 1400 feet; and magnesium chloride, one of the salts contained in this brine, is the chief raw material used in the production of the metal. This salt must first be dehydrated to remove its water of crystallization, after which it is fused and electrolyzed. The extreme lightness of the magnesium thus formed is at once apparent as it is found floating on the surface of the molten bath. After refining, the metal analyzes as high as 99.0 to 99.5 per cent pure, with magnesium oxide, iron and carbon as the chief impurities.

In developing commercial uses of magnesium, cognizance necessarily must be taken of its more important chemical and physical properties. Largely because of its lightness and the effect this would have on the reciprocating parts of an engine, its use as a piston material was early suggested and when preliminary tests indicated great possibilities all energy was devoted to this field. While the physical properties of commercially pure magnesium are such as to recommend it for certain purposes, many of them can be improved materially by alloying it properly with small quantities of other metals. This is especially true in the selection of a piston material, although pistons made from pure magnesium have also proven quite satisfactory. A rapid survey of the field indicated that some of the more desirable combinations of physical properties are found in the magnesium-aluminum series and since they may be considered as typical representatives of dowmetal alloys, and at the same time indicate their range of adaptability, they will be studied more in detail.

Fig. 1 shows the variation in some of the more important physical properties of these alloys produced by adding increasing amounts of aluminum. Those curves designated by H. T. refer to metal heat treated for 2 hours at 800 degrees Fahr., the others to test pieces as cast. The rapid rise in strength with small amounts of aluminum is at once apparent, and if we con-

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A paper presented at the Indianapolis Convention. The author, J. A. Gann, is connected with the physical and metallurgical research laboratory, Dow Chemical Co., Midland, Mich.

fine our attention to the original castings, we find that in most properties the maximum strength is reached when the alloy contains about 6 per cent aluminum. On the addition of still more aluminum, the tensile and transverse strength rapidly decrease while the compressive strength remains practically constant. The per cent elongation and per cent reduction in area curves have been purposely omitted in order to avoid possible confusion as they would cut the other curves several times. They both begin at about 5 per cent for pure magnesium, rise rapidly to 8 to 10 per cent at an aluminum content of 4 per cent, and gradually decrease to 1 per cent at 12 per cent aluminum. The Brinell hardness is roughly proportional to the aluminum content, varying from 35 to 40 for pure magnesium content, varying from 35 to 40 for pure magnesium up to 140 to 150 for a 70 per cent magnesium, 30 per cent aluminum alloy.

The stress-strain diagrams of these alloys are similar to those of other light alloys. They are characterized by their low proportional limit and the absence of any well defined elastic limit and yield point. The curve marked "Load 0.5 per cent elongation" is empirical and represents the load in pounds per square inch required to give an elongation of 0.5 per cent on a 2-inch length. Because of the large number of alloys to be tested, it was desirable to find some value easily obtained that was proportional to the elastic limit and thus save the necessity of determining the stress-strain diagrams for all alloys. Experiments showed that the average elastic limit corresponded closely to this arbitrarily chosen load and in view of the fact that such elastic limit determinations are at best subject to considerable variation and error, the simpler but more exact load at 0.5 per cent elongation was adopted as a standard determination. Such a policy is all the more allowable because of the parallelism between this value and that of the proportional limit.

The increase in strength occasioned by heat treatment depends on the per cent aluminum present. With low aluminum content the strength is practically unaltered, but as more aluminum is added the effect produced becomes more and more pronounced, the maximum occurring at 8 to 12 per cent aluminum. Not only does heat treating increase the strength of the alloy, but it likewise shifts the position of the maximum strength toward alloys with a higher aluminum content. The proportional limit and load at 0.5 per cent elongation curves are not appreciably altered by this process. The per cent elongation curve is the same as for the original castings up to 2 per cent aluminum, and then follows the same tendency as the other heat treated curves to shift the maximum, while the Brinell hardness is slightly lowered. The explanation of these changes as well as the mechanism of heat treatment can be discussed best a little later.

The real value of dowmetal and some of its outstanding advantages are shown in Table I. The values given are either the averages of the most reliable published data or experimental data obtained in our own laboratories. The most outstanding properties are the high strength and low specific gravity. The engineering world has been anxiously searching for just this combination of properties, but heretofore the term "light alloy" has been applied to various alloys of aluminum with specific gravities ranging from 2.65 to 3.00. In dowmetal, however, we have an alloy that is decidedly lighter and whose gravity is only 1.8. Aluminum alloys average 60 per cent heavier, cast iron is four times and red brass almost five times as heavy. The full significance of this combination of strength and light-

ness becomes apparent when we calculate the specific tenacity or the strength per unit weight of metal. We then find that dowmetal is twice as strong as the ordinary aluminum casting alloys, five and one-half times as strong as cast iron and approximately twice as strong as mild steel.

Furthermore, the tensile strength does not decrease rapidly with moderate temperature rises, a property common to so many types of alloys. Repeated experiments have shown that there is no appreciable decrease in strength up to about 400 degrees Fahr., after which it falls off at the rate of 4000 pounds per 100 degrees Fahr. additional temperature rise. Duralumin with its 60,000 to 65,000 pounds per square inch tensile strength is two

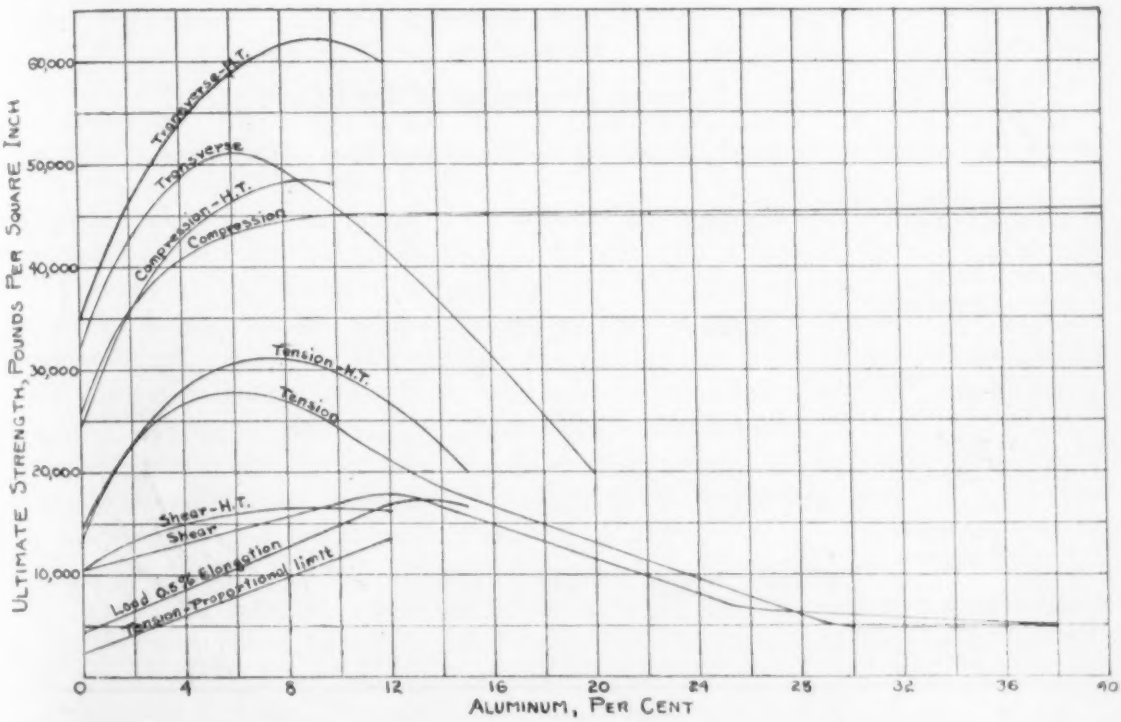


Fig. 1—Physical properties of magnesium-aluminum alloys

and one-half times as strong as dowmetal at room temperature, but is weaker at 600 degrees Fahr. This ability to retain its original strength at temperatures considerably above normal appears to be characteristic of this type of alloy although the temperature at which the break occurs varies somewhat with the composition.

Toughness is a property that is receiving more and more attention. It is now recognized that in many fields, dynamic rather than static tests give the better measure of a metal's adaptability and usefulness. When judged by the single-blow notched-bar impact test, dowmetal "A" is again shows better characteristics than aluminum casting alloys and cast iron, the relative value for these three metals being 45, 20 and 24 respectively. These figures do not represent absolute foot-pounds of energy absorbed per square inch cross section of sample, but simply indicate the relative toughness. This same fact is still more vividly illustrated by throwing on a stone floor articles such as pistons cast from these three metals, by hitting them with a sledge hammer, or by squeezing them in a vise.

Preliminary tests indicate that there is probably a direct relationship

between the single-blow impact test and the fatigue-endurance so long as we are dealing with alloys of a single type such as the magnesium-aluminum series. All comparison ceases, however, when we consider alloys with different types of structure, as illustrated by two alloys with impact numbers of 26 and 18 that withstood 200,000 and 23,840,000 reversals respectively when tested under the same maximum fiber stress.

The most recently published equilibrium diagram of the magnesium-aluminum alloys is given in Fig. 2. This work of Hansan and Gayler confirms the older results of Grube in most respects. The main points of difference are the appearance of a second small maximum at *C* corresponding to the compound Al_3Mg_2 and the claim that the compound formed at the

Table I

Comparative Physical Properties of Sand Cast Metal

Physical Property	Magnesium	Dowmetal "A"	Aluminum	Aluminum Alloy No. 12	Cast Iron
Tensile strength, pounds per square inch	14,200	25,000	13,000	20,000	18,000
Specific gravity	1.7	1.8	2.7	2.9	7.2
Specific tenacity, pounds per square inch	8,300	14,000	4,800	7,000	2,500
Elongation, per cent	5	4	25	2	Negligible
Compressive strength pounds per square inch	24,000	44,000	.....	.....	100,000
Thermal conductivity 20—350 degrees Cent	0.375	0.200	0.475	0.391	0.147
Thermal expansion, 20—400 degrees Cent	(0.29x10)-4	(0.29x10)-4	(0.25x10)-4	(0.25x10)-4	(0.11x10)-4
Brinell Hardness	40	55	26	60	125
Melting point, Degrees Cent	651	615	658	625	1,100

rounded maximum *E* is Al_2Mg_3 and not Al_3Mg_4. Still more important, however, are the positions of the solidus lines *AH* and *GK*, which indicates the ranges of solid solution. In Grube's diagram the lines *AH* and *GK* coincided with the temperature axes and so excluded the formation of any solid solution. The present diagram, however, states that each metal is capable of dissolving about 10 per cent of the other. No attempt has been made to check this value, but the photomicrographs that follow prove that magnesium can hold at least 8 per cent aluminum in solid solution. The question of the number of compounds formed between the two metals and their composition is not of importance here. The physical properties of the alloys in which we are now interested, that is, of the magnesium alloys containing small percentages of aluminum, are chiefly determined by the positions of the eutetic point *F* and the solidus line *GK*, and by the properties of the compound Al_2Mg_3, of magnesium, and of the solid solution of aluminum in magnesium. Both magnesium and the solid solution of aluminum in magnesium are soft but tough and strong. The compound on the other hand is hard, weak, and brittle. By properly regulating the proportion of eutectic to ground mass we can control the physical properties within certain limits.

Fig. 3 shows the microstructure of commercially pure magnesium mag-

nified 200 diameters. We have here the typical structure of a pure metal composed of irregularly shaped polyhedral grains. A considerably lower magnification would be better in this instance and possibly in the lower per cent aluminum alloys, but it is more desirable to keep the magnification constant so as to convey a more accurate impression of the decrease in grain size as the aluminum content is increased.

Fig. 4 shows the structure of a 2 per cent aluminum alloy. The few dark spots represent eutectic, although it was previously stated that magnesium can hold 10 per cent aluminum in solid solution. The castings have cooled so rapidly that there was not sufficient time for complete equilibrium to be established, as the solution of aluminum in magnesium is largely a time factor. A 4 per cent aluminum alloy is shown in Fig. 5. We now find more small globules of eutectic and furthermore find numerous instances where these globules are joined together into a branched chain-like structure. Fig. 6 shows a 6 per cent aluminum alloy in which the chain-like structure is now well developed. It should be remembered that this is the composition at which the maximum in the tensile strength curve occurred. An occasional crystal boundary line is still visible, indicating that the eutectic does not yet dominate the properties of the alloy.

Dowmetal "A", physical properties for which are given in Table I, is an 8 per cent aluminum alloy. As illustrated by Fig. 7 the eutectic is now beginning to surround the magnesium crystals and Fig. 1 tells us that at the same time the tensile strength is beginning to fall off. This slight decrease in tensile strength, however, is more than offset by the corresponding gain in other properties, especially hardness and rigidity. This alloy possesses an exceptionally good combination of physical properties and in many instances has proven its worth as a casting alloy.

Further additions of aluminum yield increasing amounts of eutectic. This, in turn, results in a gradual decrease in size of the primary magnesium crystals and a more complete enveloping of the same by the eutectic until they finally appear as small islands in a sea of eutectic. This transition is illustrated by the 15 and 20 per cent aluminum alloys shown in Figs. 8 and 9. Fig. 10 shows the well developed eutectic structure in an alloy containing 31 per cent aluminum, which is very close to the true eutectic composition.

Heat treatment of these alloys produces marked changes in their microstructure which can be attributed to an increase in the amount of solid solution at the expense of the eutectic originally present. Since solution in a solid medium is largely a question of diffusion and this, in turn, largely a question of pressure and temperature, we should expect the time required for complete heat treatment or complete solid solution to be a function of the temperautre, and experiments have proven this. For example, in dowmetal "A", complete solid solution is produced in 4 hours at 820 degrees Fahr., while 24 hours are required at 750 degrees Fahr. Higher temperatures unquestionably would shorten this time if we could use them, but we are limited here by the melting point of the eutectic alloy, namely, 824 degrees Fahr. It is essential that the temperature be carefully regulated especially when using the higher temperature. This is easily accomplished with an electric furnace equipped with an automatic temperature control. An electric furnace, manufactured by the Modern Equipment Co., Taunton,

Mass., has given good satisfaction as it will continually maintain a constant temperature of plus or minus 1 to 2 degrees Fahr.

If we heat treat an alloy for different lengths of time and then examine the specimens microscopically, we are able to follow the development of the solid solution structure. This is best shown in an 8 per cent aluminum alloy as we then have considerable eutectic and at the same time are far enough away from the saturation limit to get complete solid solution in a

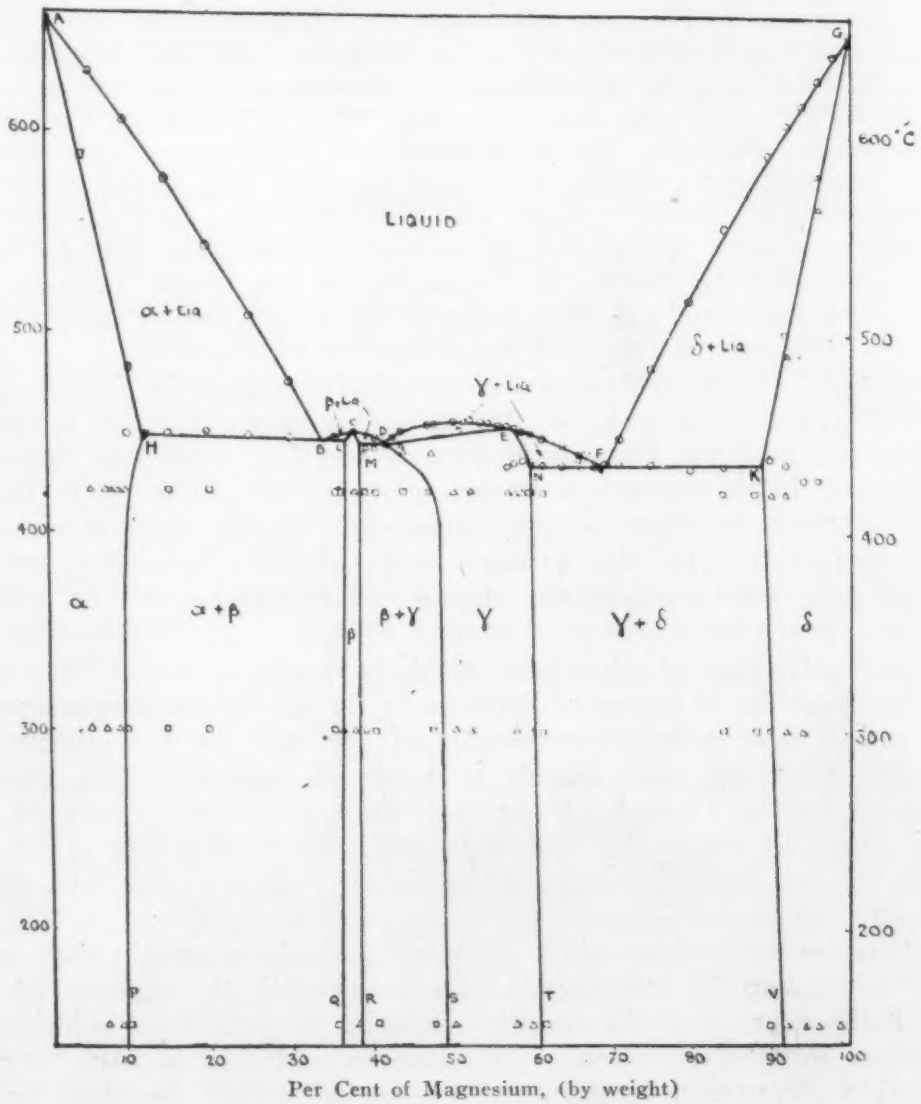


Fig. 2—Magnesium-aluminum equilibrium diagram

reasonable time. Fig. 11 shows the original casting containing the proper amount of eutectic. If this particular alloy be heated for one hour at 820 degrees Fahr., the structure shown in Fig. 12 results. The original chain-like arrangement of the eutectic is beginning to break up, with the result that the large primary crystals are not so completely inclosed by the former. Fig. 13 shows the effect of two hours heating at 820 degrees Fahr. The eutectic has now largely disappeared and the boundary outlines of the solid solution crystal grains are beginning to appear. Four hours at this same temperature gives the well developed solid solution structure repro-

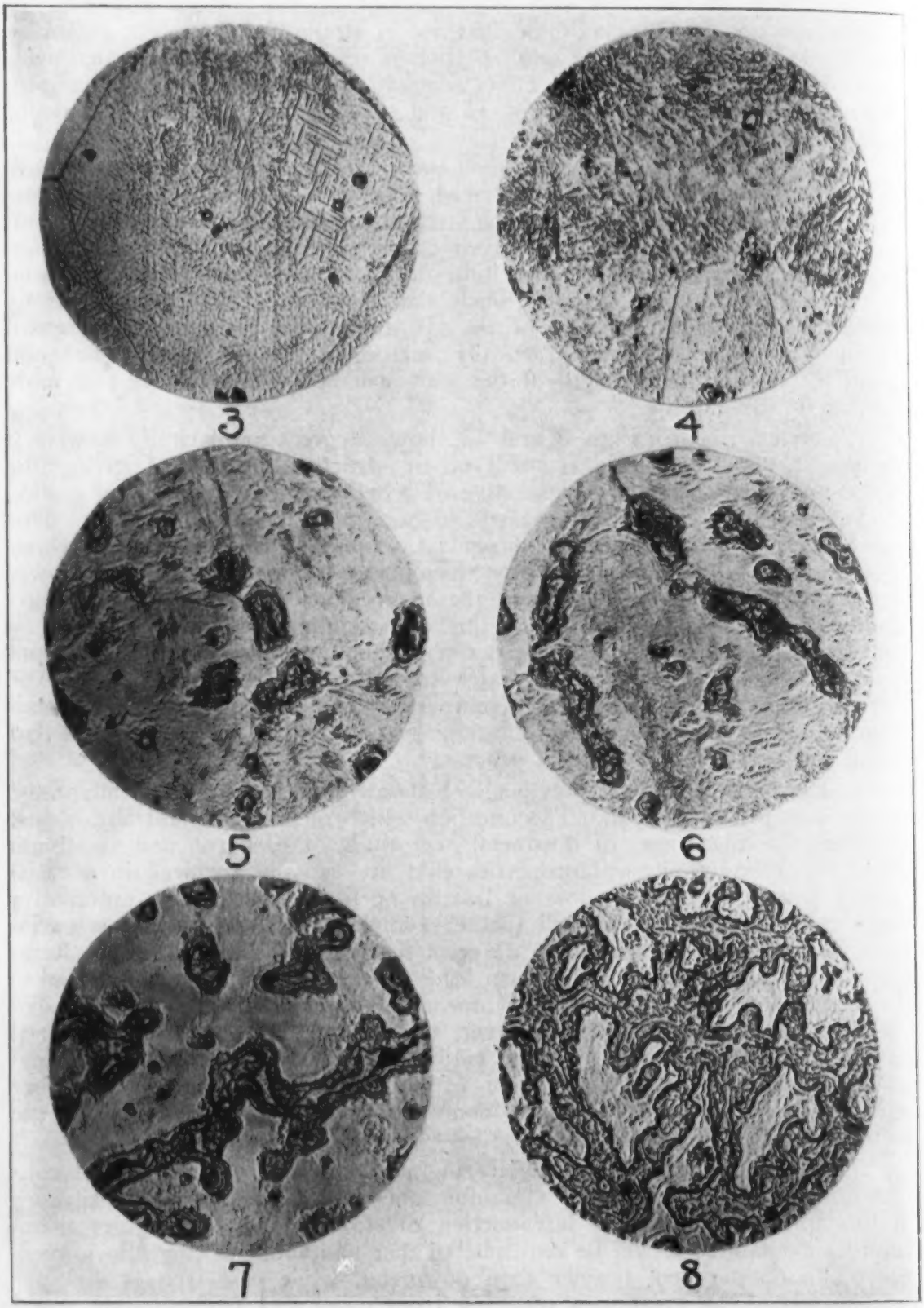
duced in Fig. 14 with only very small amounts of the eutectic visible at the crystal junctions. The maximum increase in strength due to heat treatment occurrs long before complete solid solution is reached. Repeated experiments have shown that this maximum effect is reached when heat treatment has produced the structure shown in Fig. 12 and then remains constant in spite of further changes in microstructure.

The physical property curves now become more intelligible when studied in conjunction with the above described microstructure changes. The function of the eutectic in increasing the strength of the alloy is somewhat comparable to that of steel in reinforced concrete. Exactly the same reasoning explains the increase in Brinell hardness as more and more aluminum is added. It was mentioned previously that magnesium is tough and strong while the eutectic is weak and brittle. If the eutectic is therefore increased to such an extent that it practically surrounds the magnesium, or solid solution, crystals, the strength of the alloy will be governed more and more by that of the eutectic.

A comparison of Figs. 6 and 12 shows a great similarity. Likewise it should be noted that this is the type of structure capable of giving the maximum tensile strength, irrespective of whether it be produced by casting a 6 per cent or by heat treating a still higher per cent aluminum alloy. This leads to the conclusion that the beneficial action of heat treatment is closely related to the breaking up of this enveloping eutectic structure. The lower the per cent aluminum, the fewer the magnesium crystals completely surrounded by eutectic and the smaller the corresponding increase in strength on heat treating. Similarly, in higher per cent aluminum alloys more magnesium crystals are inclosed and the greater the effect of heat treatment. The strength of heat treated specimens continues to rise with increasing aluminum content until the amount of enveloping eutectic is in excess of that which can be broken up by this process.

It has been mentioned previously that dowmetal is now being advocated chiefly as a piston material. The question which then arises naturally is just what are the advantages of dowmetal over those of cast iron and aluminum alloys. The exact physical properties that are actually required in a satisfactory piston material is more or less an open question among automotive engineers. The problem is still further complicated by the fact that variations in certain properties of the different metals can be overcome by alterations in piston design. This in turn leads to the question of the mechanical performance of the engine and so opens up opportunities for endless discussions. The fact remains, however, that up to date no piston material has been produced that has proven entirely satisfactory. The present dowmetal piston alloy overcomes some of the undesirable qualities of other metals to such an extent that it looms up as the piston material of the future.

The general trend in the engineering world is toward light weight construction, and the discovery of aluminum alloys was hailed as a big advance in this direction. With the introduction of dowmetal, a still lighter metal becomes available. It will be remembered that aluminum casting alloys average 60 to 65 per cent heavier than dowmetal, while cast iron is 400 per cent heavier. The great gain resulting from using this featherweight metal in the reciprocating parts of an engine is apparent at once. Both block and service tests indicate a great decrease in motor vibration which gives a smoother running car, added length of life to bearings, and greater



Photomicrographs of magnesium-aluminum alloys showing the decrease in grain size as the aluminum content is increased. All specimens etched with 2 per cent nitric acid and X 200. Fig. 3—Commercial magnesium. Fig. 4—Aluminum 2 per cent. Fig. 5—Aluminum 4 per cent. Fig. 6—Aluminum 6 per cent. Fig. 7—Aluminum 8 per cent. Fig. 8—Aluminum 15 per cent

speed. A recent test by the Bureau of Standards on a certain engine showed that with standard cast iron pistons and steel connecting rods, the engine produced a maximum speed of 2400 revolutions per minute, but that on replacing this standard equipment with dowmetal pistons and connecting rods, a speed of 4400 revolutions per minute was obtained easily. This great gain in speed is a fact that recently has been taken advantage of by automobile racers. Practically all the Michigan races held this summer have been won by dowmetal equipped cars. In one instance, the preliminary races eliminated all but four cars and every one of these four had pistons of this new metal. The crowning achievement, however, occurred when dowmetal pistons carried Tommy Milton to victory in the great international race held in Indianapolis last Memorial Day.

Nonabrasiveness is another property that is fundamental and inherent in this metal. It is the only piston material that does not wear or score the cylinder. The pistons may seize because they are installed with too small clearance, or because of faulty lubrication or other motor ailments, but the cylinder block is never damaged and only in extreme cases do the pistons suffer. This can be largely attributed to the absence of hard spots and sharp needle-like crystals in the metal and also to the comparative softness of the alloy.

The absence of permanent growth and its accompanying evils—warping and distortion—are likewise characteristic of dowmetal. Their effect on poor piston fit and the binding of rings in the grooves is all too well known and needs no elaboration.

Time alone can tell what the future uses of dowmetal will be. The general characteristics of this metal indicate an extremely wide range of adaptability. Its physical properties select it as the proper choice for those construction parts where strength coupled with extreme lightness is of prime importance. The use of dowmetal as a connecting rod has been mentioned, but work along this line is in the most elementary stages. Other fields open for investigation are differential and motor housings, rear axle castings, and similar parts where there is a possibility of reducing the unsprung load of a car by the substitution of a still lighter alloy for those used at present. The aeronautical world likewise offers vast opportunities, whether it be in the structural members only or also in the wing coverings of the all-metal plane. These, however, are as yet unattacked and unsolved problems. Special alloys will have to be developed that satisfy the individual requirements in each case,—a problem well within the range of possibility.

Discussion of Mr. Gann's Paper

MR. GORDON: You spoke about heating those for an hour or two hours' time at 800 degrees Fahr. That is just below the effusion point of your metal. The metal is effused at 815 degrees Fahr.

DR. GANN: 824 degrees Fahr. is the melting point of the eutectic.

MR. GORDON: After they have been heated to that temperature, are they quenched in the furnace or in the open?

DR. GANN: We simply air cool. Due to the fact that this line *KV* in Fig. 2 comes down practically straight there is nothing to be gained by quenching. We have tried quenching, air cooling, and furnace cooling, and get practically the same results in all cases.

MR. PORTER: In connection with the assembling of the pistons, what is the capacity of the metal to retain parts assembled as compared

with cast iron? In other words, you drive a pin into cast iron and there is a rigidity in cast iron that holds that pin. This metal is soft and it seems the hole would enlarge from the shock.

DR. GANN: No sir. We have run cars with unbushed pistons for 15,000 to 20,000 miles with very satisfactory results. We have tried bushed pistons, but at the present time we are in favor of the unbushed pistons.

PROFESSOR HARDER: What technical reasons do you give for the heat treatment of this alloy?

DR. GANN: We thought it was necessary at one time in order to gain greater strength, but as it now stands, dowmetal "A" and also other alloys that have been used are all stronger than ordinary aluminum casting metals thus we are not heat treating. Furthermore, that eutectic is highly desirable. It gives a rigidity which is not obtained in the solid solution type of structure.

CHAIRMAN BOYLSTON: What is the significance of the small polyhedrons in the solid solution structure?

DR. GANN: That is a point we don't really understand. From a composite photograph of Figs. 11 to 14 we are not sure what it does mean but we think it gives an indication of the amount of solid solution present in the original casting. Referring to the original casting, Fig. 11, it will be seen that in the center of the large white area, there is practically none of the secondary structure. Referring to Fig. 12, it will be found that the secondary structure extends practically across the alloy, which we think indicates how far the solid solution extends away from the eutectic. However, that is a problem we have not solved.

CHAIRMAN BOYLSTON: What etching solution do you use for developing?

DR. GANN: A 2 per cent solution of nitric acid and water for about 5 to 10 seconds, depending on the temperature and the nature of the alloy.

MR. CLARY: In the running of pistons without bushings have you noticed that there is any apparent hardness that is greater after the piston has been run, as between the pin and piston, than in the original metal, due to grazed or otherwise affected surface?

DR. GANN: I imagine there would be. By forging magnesium or its alloys you can increase the hardness. While dowmetal "A" is not a forging alloy, we have forged a few pieces and the hardness has been increased from about 50 to 55, up to 75 and 80, but what the effect is in the bushing we have never determined. Undoubtedly the hardness is higher than in the unused piston.

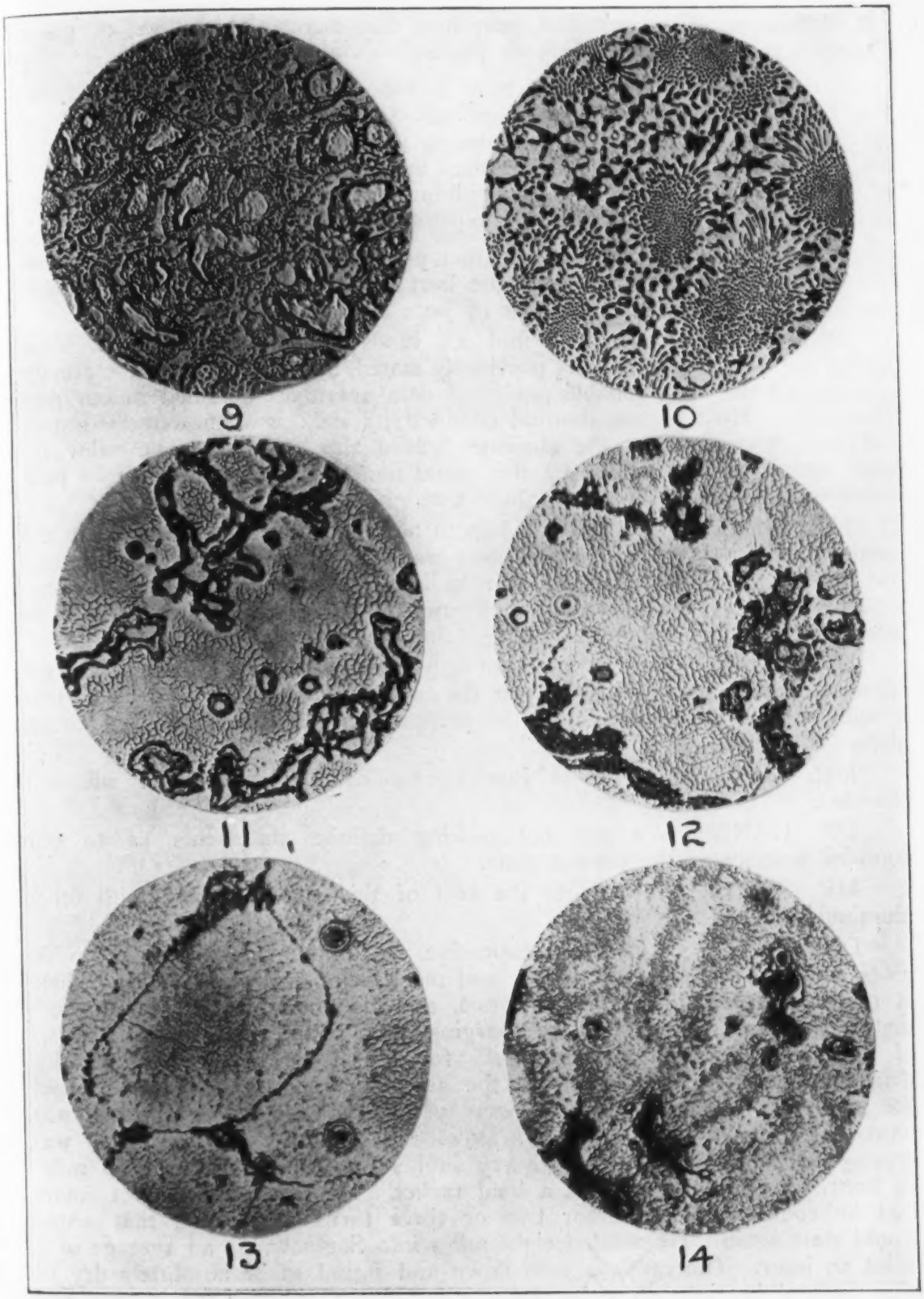
MR. CLARY: Apparently there is a grazed surface that takes place after a short time.

DR. GANN: We have never determined the hardness, so I could not definitely say, but I imagine it would be harder.

MR. SCOTT: What is the shrinkage that you allow for in the sand castings?

DR. GANN: One-eighth of an inch per foot.

MR. MCCLOUD: I noticed that the expansion, the linear expansion given for the dowmetal and also for magnesium was considerably higher than aluminum or cast iron, and also that the conductivity was lower than



Figs. 9 and 10—Photomicrographs of magnesium-aluminum alloys showing the decrease in grain size as the aluminum content is increased. Etched with 2 per cent nitric acid and X 200. Fig. 9—Aluminum 20 per cent. Fig. 10—Aluminum 31 per cent. Figs. 11-14—Magnesium-aluminum alloys of 8 per cent aluminum content showing effect of heat treatment. Etched with 2 per cent nitric acid and X 200. Fig. 11—Original casting of 8 per cent aluminun.. Fig. 12—Aluminum of 8 per cent heat treated 1 hour at 820 degrees Fahr. Fig. 13—Aluminum of 8 per cent heat treated 2 hours at 820 degrees Fahr. Fig. 14—Aluminum of 8 per cent heat treated 4 hours at 800 degrees Fahr.

for aluminum. For instance, how does that affect the amount of piston clearance you have to give in your pistons?

DR. GANN: When any new piston material is brought forward you have to change the design, and all our pistons in the different types of cars had to be redesigned in order to meet these properties. The piston head is made considerably thicker than in the case of cast iron, and somewhat thicker than in the case of aluminum. This gives greater conductivity and the question of co-efficient of expansion is largely overcome.

MR. MCCLOUD: I looked that point up out of curiosity and some figures that I found stated that the heat conductivity of pure magnesium was considerably greater than that of pure aluminum.

DR. GANN: You will find all kinds of data. We think these figures are nearly correct. As previously stated, all values given here are the averages of the most reliable published data or values obtained in our own laboratory. Most of the thermal conductivity data is from our laboratory and was determined by the absolute "guard ring" method. The value for other metals as determined by this same method, checked previously published data so we believe the values here given are nearly correct.

MR. MCCLOUD: I would like to ask regarding the technique in the handling of the metal. I believe there was a German patent concerning the use of a small amount of calcium to keep down the oxidation of magnesium alloys. I wondered if any use of that idea is being made in this country.

DR. GANN: The Germans not only claim that the addition of a small amount of calcium will keep down the oxidation, but they also claim that it will increase the hardness. At the present time we have done little work along that line.

MR. MCCLOUD: It is just a case of blanketing with sufficient charcoal.

DR. GANN: We are not making definite statements as to our foundry practice at the present time.

MR. SCOTT: How does the cost of this alloy compare with other aluminum alloys?

DR. GANN: It is more expensive. Aluminum is about 25 to 30 cents a pound in the open market, and magnesium is around $1.25. There is quite a decided difference in price, and dowmetal alloys are approximately the same price. We are charging $2 a pound for castings. A set of machined Ford pistons, plain, sells for $24. They are more expensive than aluminum or cast iron, but the advantage gained more than offset the price, for example, we have never yet had a case where a piston was scored. A short time ago, Mr. Dow, the manager of the plant, was driving to Saginaw in a great hurry in his Cadillac roadster at 50 miles an hour. Suddenly there was a loud racket. He stopped and then found that he could spin the motor two or three turns whereupon that sound would start again. He coasted eight miles into Saginaw, on an average of 5 miles an hour. The car was torn down and found to be absolutely dry of oil. Several bearings were burned out but not a cylinder was scored and even with that drastic treatment only two of the pistons were scored on the side, but not enough to hurt their performance. The same pistons were put back into the car with highly satisfactory results. We have had several other instances of a similar nature, but the cylinder has never been scored.

When you consider the cost of re-boring and fixing up the cylinder it more than offsets the original cost of the pistons.

MEMBER: Do you have any trouble with metal burning?

DR. GANN: Not if proper caution is taken.

MR. GORDON: You spoke about forging. At what temperature?

DR. GANN: The only satisfactory forgings that we have had have been made from alloys of different compositions than those discussed in this paper. We used a temperature of approximately 600 to 650 degrees Fahr. Other conditions were similar to those used in standard steel forging practice.

FRACTURE TEST ON STEEL TO DETERMINE ITS QUALITY

By W. J. Priestley

THE bulk of steel entering into finished machine parts in this country is forged, heat treated, and machined in other plants than the plant in which it is melted and cast. Large quantities of high grade alloy steel, high carbon steel, and tool steel are handled in this manner. The consumer purchases the steel on its chemical analysis and surface inspection, no reference being made to the record of manufacture other than that the steel shall be made by the acid open-hearth, basic open-hearth, electric or crucible process. In some cases, the method of melting is not specified.

Frequently it happens that steel purchased in this manner is rejected after heat treatment or after machining due to defects which were not apparent in the purchased bloom, billet, or bar stock. Due to the fact that a customer may purchase only a small portion of the original heat of steel, it would be impracticable for him to demand with his purchased order of steel, the melting record of this steel; furthermore, if this record were furnished, the consumer might not be able to interpret the same intelligently and know whether or not he was getting a satisfactory heat of steel.

In cases where complete detail record of manufacture of steel forgings have been available, it has been found that a simple fracture test taken from the end of a forging, billet, or rolled bar stock, furnishes more conclusive data than many other tests which are more elaborate and more expensive. This test has been used for some time past for determining pipe in rolled stock. In this instance, the plane of the fracture is at right angles to the direction of rolling. Purchasers of high grade alloy steel and tool steel will find a fracture test equally serviceable and practicable for a determination of slag, inclusions, flake, blow holes, pipe, and excessive segregation, if taken so that the plane of the fracture is parallel to the direction of forging or rolling.

The test consists of sawing a disk about 1¼ inches thick from one end of the forging or bloom. If this small disk is quenched slightly above its critical temperature, drawn between 900 and 1100 degrees Fahr., and then broken in two, it will give a fracture parallel to the direction of forging or rolling which will disclose the texture of the metal. Flake, slag, blow holes, pipe and excessive segregation may be detected easily by means of this fracture test.

This test should supplement the usual test for chemical analysis and surface inspection. It affords a means of rejecting, before forging, heat treating and machining, any steel which contains any of the foregoing defects. In many cases steel with inherent defects is taken up for manufacture and when finally rejected, is blamed upon improper heat treatment on account of not having knowledge of these inherent defects.

Figs. 1 and 2 show disks taken from forgings as large as 10, 13, and 18 inches in diameter. It will be seen from Fig. 1 that the disks were broken with great difficulty after a single quench and draw. The way in which these disks bent without breaking gave almost positive proof

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A paper presented at the Indianapolis Convention. The author is superintendent of the hot metal division, United States Naval Ordnance Plant, Charleston, W. Va.

that subsequent tensile tests from these forgings would be satisfactory. Four bars taken at right angles to the direction of forging of these blooms showed the following physical results:

Tensile strength pounds per square inch	Elastic limit pounds per square inch	Elongation per cent	Reduction in area per cent
95,400	61,000	25.2	53.2
97,500	68,300	26.	58.1
100,000	62,500	23.6	50.8
100,100	68,400	23.6	50.5

Attention is invited to the fact that these bars were taken at right angles to the original axis of the ingot and across the grain with respect to the way the metal was forged. This steel was 0.38 per cent carbon, and about 2.75 per cent nickel.

Fig. 1—Disks taken from 0.38 per cent carbon, 2.75 per cent nickel steel forgings and broken with great difficulty after a single quench and draw. The way in which they bent without breaking gave almost positive proof that tensile tests would be satisfactory

Fig. 2 shows three similar disks taken from other blooms. The top disk discloses minute inclosures of slag in the fracture. These may be seen by closely examining the photograph. They are about as wide as a needle and vary from ¼ to ½-inch in length. Physical test bars taken from this forging at right angles to the axis showed the following physical tests:

Tensile strength, pounds per square inch	94,000
Elastic limit, pounds per square inch	70,000
Elongation, per cent	12.2
Reduction in area, per cent	30

The middle disk, Fig. 2, shows a fracture of steel which is almost entirely free from slag or other impurities. Tensile bars taken from this disk showed the following:

Tensile strength, pounds per square inch	97,000
Elastic limit, pounds per square inch	70,000
Elongation, per cent	26.4
Reduction in area, per cent	62

The bottom disk, Fig. 2, contains bright silky spots, generally termed "snow flakes". These are very easily distinguished in the photograph. A tensile bar taken at right angle to the axis of this forging showed the following:

Tensile strength, pounds per square inch	94,900
Elastic limit, pounds per square inch	67,500
Elongation in area, per cent	11.4
Reduction in area, per cent	24.9

This information is furnished with the idea that it may be of some benefit to heat treaters who do not melt their own stock but purchase it in the form of blooms, or billets. This is an inexpensive test and could be taken at the rolling mills or forge plants before shipment to the ultimate consumer. The saving effected by rejecting unsatisfactory steel before machining and heat treating would more than offset the slight cost of taking fracture tests of forgings, blooms or bar stock.

Fig. 2—Three similar disks taken from blooms. The top disk discloses minute inclosures of slag in the fracture. The middle disk shows a fracture almost entirely free from slag or other impurities. The bottom disk shows bright silky spots known as "snow flakes"

ROMANCES OF METAL WORKING—TWO FAMOUS ARMORERS

By H. H. Manchester

IN THE 15th century the two great schools of armor making were the Italian and the German, which had by this time surpassed in quantity, if not in quality, the famous Toledo blades of Spain.

In Italy the armorers were located in all of the principal cities, with those of Milan, Florence, and Venice perhaps the most famous. A representative armorer of Venice was Vittore Camelio, who also developed a rather important step in metal working.

He lived in the latter half of the 15th century, and was noted for his light steel armor of a very high temper, as well as for the elasticity and indestructibility of his swords.

Camelio was not only an armorer, but a medal maker and an engraver. One day, so the legend runs, he used one of his swords to slice off a bar of gold which had been sent him for medals. This was done so easily that he realized more than ever the fact that he could produce steel which would cut the other metals. From this idea, he developed a steel die, which he used at first to cut out the blanks for medals, and later, it is said, to stamp the face of a coin. At any rate, the senate of Venice in 1509 gave him a patent for this device for five years, which is comparatively good proof that there is much truth in the story.

A fair representative of the German school of armor making was Conrad Seusenhofer, who lived in the last of the 15th and the first of the 16th century.

In 1504 we find him enlarging his workshops at Insbruck with money advanced from the government, but later we find that this was to be deducted from his pay.

He developed the fluted style of armor, which was for some years the height of fashion, and evolved a number of special tools to produce this. Another tool of importance which he is credited with improving, is the heavy shears which could cut thin plates of iron.

He developed several new methods of armor plate construction, but these were not at all in favor with Maximillian, the emperor, who said to him: "Make my armor only in accordance with my instructions, for it is I, not you, who must wear it."

In 1511 Seusenhofer complained that the mine master, Kugler, was sending him poorer metal, and suggested that the armor plate from it be called Milanese, which indicates that he thought the Innsbruck steel better than the Italian. It also shows that at that time the quality of the steel produced could not be altered at will by the smith, but depended largely on the nature of the iron with which he had to work.

The armorers of the time were always having trouble collecting the pay for their work, and frequently the only method of assuring it, was not to deliver the armor until paid for. Seusenhofer was apparently using this method to collect from Maximillian, or his government, during one of the wars of the period. This finally led to there being a shortage of armor, whereupon Maximillian in wrath sent word that if the armor were not forthcoming that the armor makers would be put in the front rank without armor, so that they could appreciate for themselves how it felt to fight without proper protection.

Reprinted from page 404 of the March 16 issue of the *American Machinist*.

Comment and Discussion

Papers and Articles Presented Before the Society and Published in Transactions Are Open to Comment and Criticism in This Column—Members Submitting Discussions Are Requested to Give Their Names and Addresses

CORRECTS CARBON CONTENTS

IN THE paper "Do Alloy Carbonizing Boxes Pay?" by C. M. Campbell, which appeared on page 495 of the March issue of TRANSACTIONS, the author desires to correct two errors which appeared in the original manuscript. In the first line of the last paragraph on page 495, the word "over" should read "under," thus the line should read "An iron-chromium silicon alloy which analyzes: Carbon under 0.50." In the last line of the third paragraph on page 496, the word "less" should read "greater," therefore the corrected sentence will read "This iron-chrome-silicon alloy can be cast in either green or dry silica sand molds when the carbon content is greater than 0.25 per cent."

BRINELL HARDNESS FIGURE APPEARS IN ERROR

THROUGH typographical error one of the actual Brinell hardness figures was given incorrectly in the paper "New Development on the Influence of Mass in Heat Treatment" by E. J. Janitzky, which appeared on page 377 of the February issue of TRANSACTIONS. On page 381 in the second column headed "Actual Brinell hardness," the figure in the fifth line should appear as 248 instead of 348.

The Question Box

A Column Devoted to the Asking, Answering and Discussing of Practical Questions in Heat Treatment—Members Submitting Answers and Discussions Are Requested to Refer to Serial Numbers of Questions.

QUESTION NO. 5. *What is needle bar stock?*

QUESTION NO. 6. *Does the temperature in the carbonizing box or pot at any time become greater than that of the furnace in which it is being heated?*

QUESTION NO. 7. *May tools be heat treated properly in a furnace in which copper is present?*

QUESTION NO. 8. *What is the effect of high and low silicon in tool steel?*

QUESTION NO. 9. *In carbonizing does not the carbon increase slightly even in the core section?*

QUESTION NO. 10. *What surface of steel, that is, machined, cold rolled, hot rolled or cold drawn, carbonizes fastest and why?*

QUESTION NO. 11. *Has high speed steel ever been carbonized and if so what were the results?*

QUESTION NO. 12. *How and why is cast iron heat treated? Is there such a process as ageing or seasoning castings other than by annealing?*

QUESTION NO. 13. *A swaging die for tubing receives* 3600 *blows per minute. It has been found that a scleroscope hardness of about* 95 *is necessary to prevent excessive wear. When this hardness is obtained considerable trouble is encountered in warping during heat treatment. Is there any steel in which this hardness can be procured without warpage?*

QUESTION NO. 14. *What can be done to prevent coiled strip stock from sticking together when annealed? This stock is bright rolled, wound into coils and pack annealed and the coils sometimes stick together. It cannot be softened by heating below the critical range for fear of grain growth due to critical straining.*

QUESTION NO. 17. *For some time past we have been water quenching steel castings in order to improve their physical properties. These castings are mostly shrouded pinions and plain rollers, weighing from* 150 *to* 500 *pounds each. These pieces would be immersed in the water bath for a short period of time, usually from one to two minutes and then withdrawn and*

allowed to cool in the air. Our results have been satisfactory but we feel that we can improve this method somewhat by a slight modification in the treatment. In order to relieve cooling strains, one suggestion is that we provide a tank filled with infusorial earth in which the castings would be placed in order that cooling might be slow and uniform. Another suggestion is that instead of using a plain water bath, we introduce sodium hydrate in order that the quenching may not be quite so severe. We would like to know which of the above plans would be the better or if there is any other better plan which could be suggested. We do not care to use oil because of its expense.

NOTE. Rollers may break in the flange a month or more after above treatment. Loss at present is 2 per cent. Pinions, after above treatment, are drawn in furnace to 1200 degrees Fahr. for toughness. If drawn shortly after quenching there is no trouble, but this is not always practicable when working day turn only. If allowed to stand in air after quenching, cracking may result, hence the suggestion for covering with infusorial earth or ashes. We have had only one batch to show cracks.

ANSWER. By A. H. Putnam, testing engineer, 1710 East Twelfth street, Davenport, Ia. It is extremely difficult to make suggestions which will lessen the loss from cracks after quenching steel castings without having more information of this particular case. Some of the factors which are directly or indirectly responsible for these cracks will be outlined briefly below.

It is imperative that the approximate chemical composition of each lot of castings be known as it will be necessary to regulate the quenching and drawing temperatures accordingly. No doubt the loss from cracks will be larger in the casting heats showing a higher carbon content than from heats with a lower carbon content. The method of annealing which is used prior to heat treatment is often responsible for cracks in quenched castings when the original casting structure is not broken down by a sufficient anneal. If ferromanganese or ferrosilicon additions are made in the ladle just prior to pouring castings and the ferroalloys have not completely diffused, this will no doubt cause trouble when the castings are quenched. The length of time the castings are allowed to soak just prior to quenching is very important. The length of time the castings are held at the drawing temperature is more important. The length of time the castings are allowed to remain in the quenching bath will depend largely upon the carbon content and the shape and weight of the casting being quenched. The physical properties which are desired will to a large extent regulate the heat treatment. If the physical properties required are not too severe, often times an air quench or cooling in an air blast from a temperature above the upper critical point and using a low draw will furnish the desired results.

QUESTION NO. 18. ***What is the relationship between Brinell and Scleroscope hardness?***

ANSWER. By J. Fletcher Harper, research engineer, Allis-Chalmers Mfg. Co., Milwaukee.

At various times the members of the society have brought up the question as to the relation which exists between the Brinell and scleroscope numbers. The Allis-Chalmers Mfg. Co. has prepared the accompanying two charts with this information for the guidance of their engineers.

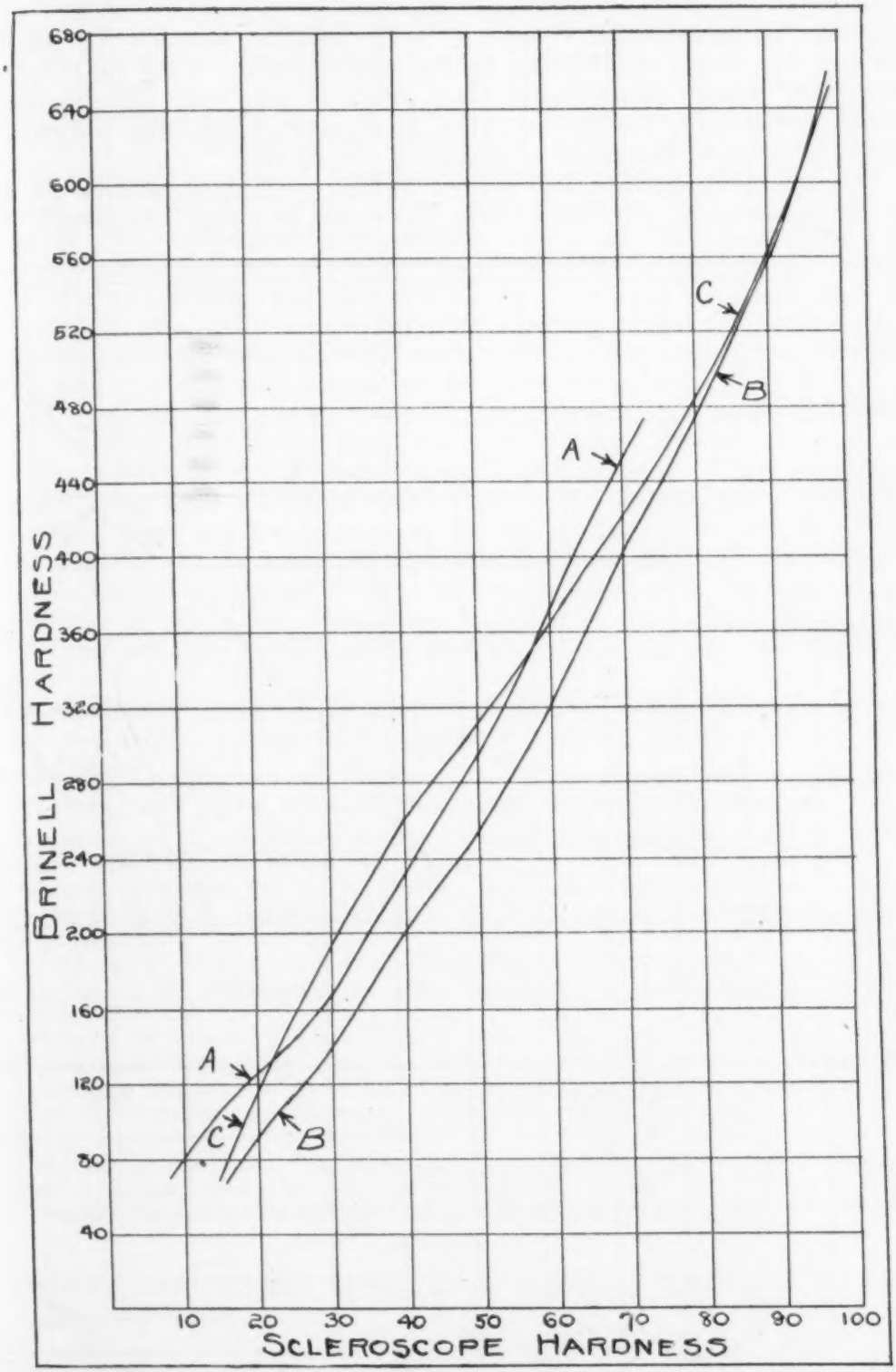

Fig. 1—Curves showing comparisons between Brinell and scleroscope hardness. Curve *A* produced by Allis-Chalmers Mfg. Co., using steel ball at 3000-kilogram pressure. Curve *B* produced by Shore using diamond ball at various pressures. Curve *C* produced by Shore using steel ball at 3000-kilogram pressure

Fig. 1 is the comparison between Brinell and scleroscope numbers. Curves *B* and *C* were prepared by A. F. Shore and were presented by him before the British Iron and Steel Institute in September, 1918. Quoting from Mr. Shore's article: "Curve *C* is the relation between the scleroscope and ball tests from the hardest to the softest metals, using 3000 kilograms throughout under 10-millimeter steel ball. It was not found possible to obtain a satisfactory conversion curve, as its wavy appearance indicates. This is probably due to the cause of excessive pressures.

"From approximately 700 Brinell to 550, wide discrepancies are caused by the flattening of the ball. From 550 down to about 200 Brinell, abnor-

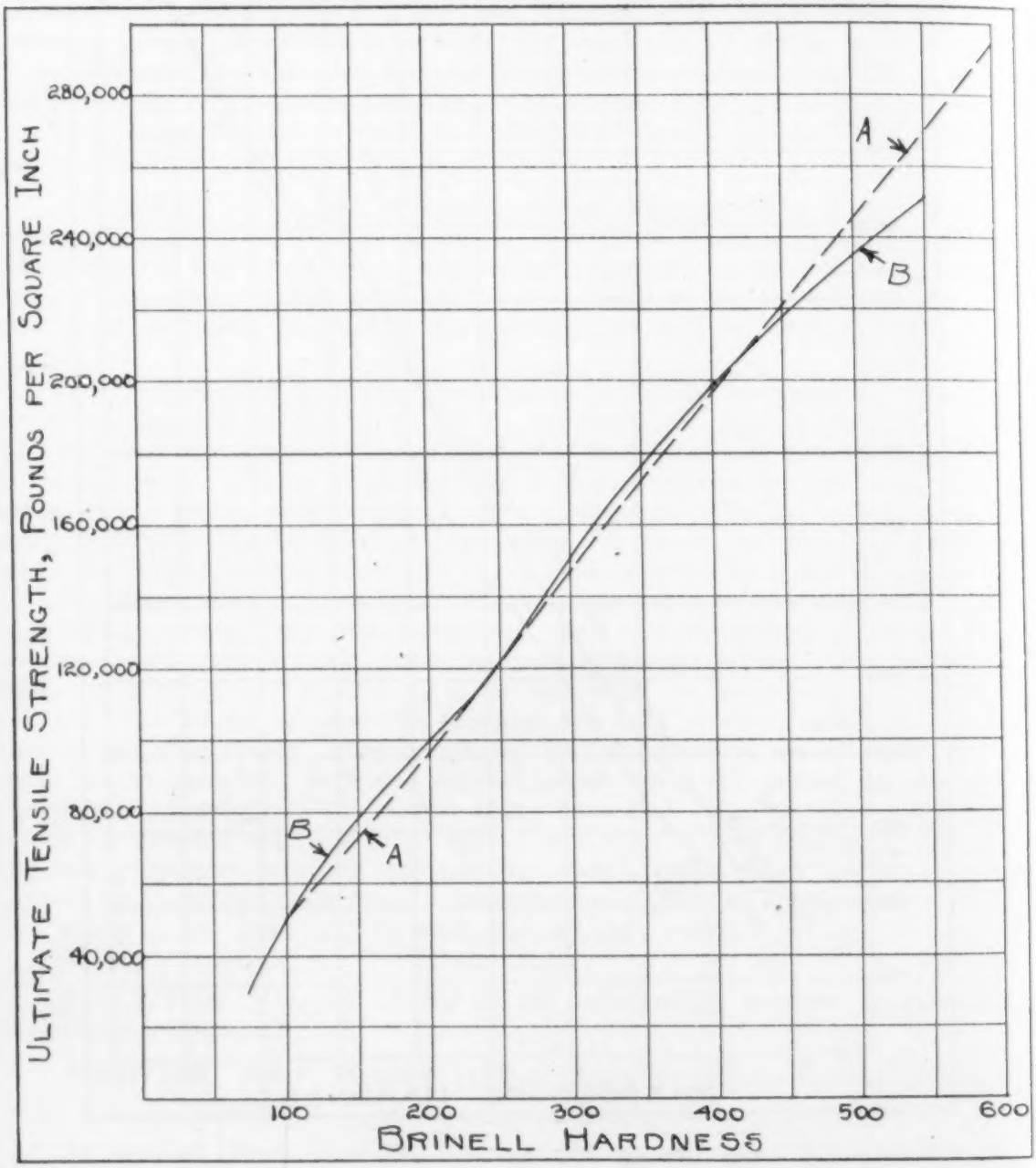

Fig. 2—Curves showing comparisons between ultimate tensile strength and Brinell hardness numbers. Curve *A* reproduced from *Making, Shaping and Treating of Steel*, by J. M. Camp and C. B. Francis. Curve *B* produced by the Allis-Chalmers Mfg. Co.

mally high readings are obtained, due to the superhardening of this series of metals, which is necessarily possessed of marked toughness. Below 250 similar superhardening occurs, but Brinell readings have a tendency to fall below the best average line, because the superhardening is neutralized by flow in the metal. In order that these tendencies may be shown more clearly, a comparison is given in curve *B*. Curve *B* is the relation of ball test and scleroscope using 62, 250, 500 and 750 kilogram pressures, respectively. Above 325 Brinell or 60 scleroscope, a diamond sphere 10 millimeters in diameter was used, because of the flattening of the steel ball."

Curve *A* is the one plotted at the Allis-Chalmers Mfg. Co., from approximately 500 readings covering various classes of materials. While this curve is subject to the same discrepancies of superhardening, etc., referred to by Mr. Shore; together with possible slight errors due to grain size, nature of surface, etc., it has been found an excellent approximation for commercial practice. All readings were made by the same two operators checking each other; and in all cases a buffed surface was used.

Fig. 2 shows the comparison between Brinell hardness and tensile strength. Curve *A* is taken from the table in the *Making, Shaping and Treating of Steel* by J. M. Camp and C. B. Francis. They publish the following: "It is both a curious and a significant fact that the Brinell hardness number bears a close relation to the ultimate strength. * * * * * * * * This relation it will be observed, is approximately 500, and holds for all grades of carbon steel whether they be heat treated or in the natural state as forged or rolled. For this reason the Brinell test is applicable to the rapid testing of steel from which sample for the tensile test cannot be obtained."

Curve *B* is the relation established between the Brinell hardness number and the tensile strength of a large number of samples by the Allis-Chalmers Mfg. Co.

Following are given some of the recent references to hardness testing:

"Comparison of Five Methods used to Measure Hardness," by Ralph P. Devries, Technologic paper No. 11, Bureau of Standards.

"Hardness Testing," by A. F. Shore, paper read before the Iron and Steel Institute Sept. 12, 1918. *Engineering*, Oct. 18, 1918, *Journal* American Steel Treaters Society January, 1919.

"The Hardness Testing of Metal," *Journal* of Mechanical Engineering, July, 1921.

"The Use of the Scleroscope on Light Specimens of Metals" by Fred S. Tritton, *Engineering*, Sept. 30, 1921.

"Hardness Variations in Heat Treated Steel," by Carle R. Hayward, *Chemical and Metallurgical Engineering*, Oct. 12, 1921.

"Scleroscope Hardness of Steel Balls," by Arthur L. Collins, *Iron Age*, Dec. 1, 1921.

"Physical Properties of Material," Bureau of Standards Circular No. 101, Feb. 9, 1921.

"The Relation Between Maximum Strength, Brinell Hardness and Scleroscope Hardness in Treated and Untreated Alloy and Plain Steels," by Robert A. Abbott, *Proceedings* of American Society for Testing Materials, 1915, Volume XV.

QUESTION NO. 20. What are the causes of warping in the heating and cooling of steel?

QUESTION NO. 22. Can ghost lines be eliminated by heat treatment?

NOTE. A difference of opinion exists on this subject as shown by the four brief answers submitted with the question. N. B. Hoffman says: Ghost lines can not be broken. The carbon can be recrystallized but the

nonmetallics remain. W. J. Merten says: Ghost lines can be eliminated by heating to a very high temperature and cooling to the critical point rapidly. Then heat treat from this point. A. M. Cox says: Ghost lines can be prevented from forming. W. B. Crowe says: Ghost lines can not be eliminated but may be modified.

QUESTION NO. 23. Why is it that a piece of hot rolled steel, of a given composition, will not harden in oil after carbonizing to the degree that a piece of the same composition will if first subjected to forging?

QUESTION NO. 24. What methods can be suggested for brazing high speed sheet steel strips together, preferably during the hardening operation? A spelter of copper, tin, aluminum and borax finely pulverized seems to interfere with the proper hardening. The portion of the tool brazed must maintain a keen edge and have good red hardness.

ANSWER. By W. L. Appel, assistant director testing department, E. C. Atkins & Co., Indianapolis. A cement is now on the market for cementing high speed steel or stellite to a low carbon base in making tools for all purposes, whether it be to lower the cost of a solid high speed steel tool or to alleviate the brittleness of a tool. The writer has had success with this cement in repairing broken high speed tools and has used it for cementing high speed steel bar stock together. Cementing is carried out in the same operation as the hardening of the high speed steel. The cement, which is in the form of a fine powder, is placed between the scale or rust-free surfaces of the steel to be cemented together. The pieces then held in the proper position are placed in the hardening furnace and heated to the desired hardening temperature. The cement melts at 2200 degrees Fahr. and acts as an alloying agent between the surfaces of the steel. After the proper hardening temperature is reached, the excess cement is squeezed out by a slight pressure and the whole quenched in the desired bath. Later this tool or high speed part may be drawn at any temperature or even annealed and rehardened.

QUESTION NO. 25. In hammering down some high speed steel scrap, first a heavy hammer then a light hammer was used to reduce the size. The pieces were packed in charcoal and annealed at 1550 degrees Fahr., with the result that a very hard case was produced. Some pieces were annealed without putting them under the light hammer and the case did not result. Open annealing was then tried on both kinds but no case was obtained. What caused the case mentioned above?

ANSWER. Charcoal under proper conditions gives internal combustion thus raising the temperature in the boxes to within the carburizing zone.

QUESTION NO. 26. Frequently checks and cracks appear in case hardened and high carbon steel parts after lapses of various times. These parts apparently come from the grinders in perfect condition. The cracks are sometimes radial and sometimes not. Regrinding and changing wheels, speeds, grades, feeds and refrigerant do no good. Why do these cracks occur?

ANSWER. I can not see where the hardening room can be blamed al-

though the steel may be dirty or faulty. However, faulty steel should show up in the hardening room. It would be well to look into the grinding and to get the advice of a grinding expert on the job. To ascertain if checks will grow, start the piece "breathing," that is, cool in kerosene to about 20 degrees below zero and heat to almost a drawing temperature. Repeat the operation several times.

QUESTION NO. 27. In grinding high speed work a soft film often is left on the piece. Why does this happen?

ANSWER. The grinding probably develops this film.

QUESTION NO. 28. Does it seem that dry grinding will generate enough heat to draw high speed steel?

ANSWER. Absolutely. It is necessary only to get above 1200 degrees Fahr. to start the softening and this is very easy as high speed steel does not give off many sparks and therefore will not give much notice of its heat.

Abstracts of Technical Articles

Brief Reviews of Publications of Interest to Metallurgists and Heat Treaters

By H. E. Gladhill

ALLOYS AND ALLOY STEELS

CHROME-MOLYBDENUM STEEL APPLICATIONS FROM THE CONSUMERS VIEWPOINT. By C. N. Dawe, *Journal* of the Society of Automotive Engineers, Vol. 10, Page 47.

Tensile tests were made on 400 heat treated test pieces of chrome-molybdenum, chrome-vanadium, chrome-nickel and chrome steels, the heat treated stock varying in size from ⅞-inch rounds to 2-inch squares. The heat treatment consisted of a quench from 1475 to 1659 degrees Fahr., depending upon the type of steel, followed by a draw. Three drawing temperatures, namely, 1000, 1100 and 1200 degrees Fahr. were used on each type of steel. Comparison of results by means of Chandler's merit index, showed the chrome-molybdenum steel to have a decided advantage over the other grades tested. Carbonizing tests with chrome-molybdenum steels did not give as uniform results as could be desired. Nickel-molybdenum steels have shown themselves more satisfactory in carbonizing operations.

THERMAL EXPANSION OF NICKEL, MONEL METAL, STELLITE, STAINLESS STEEL, AND ALUMINUM. By W. H. Souder and P. Hidnert, Bureau of Standards, Scientific Paper No. 426.

Thermal expansion curves were established for 10 samples of nickel containing 94 to 99 per cent of the element, ten samples of monel metal, five samples of various grades of stellite, two samples of stainless steel and two samples of aluminum. For all but the stainless steel, the curves cover the range from room temperature to 600 degrees Cent. For the stainless steel the curves extend to 900 degrees Cent.

MANUFACTURE AND PROPERTIES OF STEEL PLATES CONTAINING ZIRCONIUM AND OTHER ELEMENTS. By G. K. Burgess and R. W. Woodward, Bureau of Standards, Technologic Paper No. 207.

The investigations were made by the Bureau of Standards and the Bureau of Mines to furnish information to the army and navy on light armor plate. One hundred and ninety-three heats of steel containing varying combinations of the following principal variable elements: carbon, silicon, nickel, aluminum, titanium, zirconium, cerium, boron, copper, cobalt, uranium, molybdenum, chromium and tungsten were studied. Three per cent nickel steel deoxidized with aluminum gave a tensile strength of 300,000 pounds per square inch and is recommended for structural work. The action of the individual elements is described in detail.

FATIGUE FAILURE

REMARKS ON FATIGUE FAILURE OF METAL PARTS, THEIR CAUSE AND PREVENTION. By H. C. Knerr, *Forging and Heat Treating*, Vol. 8, Page 40.

The conditions which influence fatigue failure in metals are (a) the number of repetitions or cycles of stress applied in the lifetime of the piece; (b) the range of stress for each cycle; and (c) the presence of points at which stresses may become localized, such as notches, sudden changes of cross section, or irregularities in the metal, such as slag particles. A specific case of failure is sighted in which appreciable amounts of slag were found in the metal.

FERROUS MATERIALS

CONTINUOUS DIE ROLLING. By G. R. Norton, *Journal* of the Society of Automotive Engineers, Vol. 10, Page 43.

The production possibilities and manufacturing methods used in die rolling are described. The active surface of the rolls is built up from forged or cast rings instead of sinking impressions into the ordinary roll. Metallographic examination shows that this process gives a very uniform, small-grained product. Cost and equipment are discussed in very general terms.

PERTINENT FACTS CONCERNING MALLEABLE IRON CASTINGS. By Enrique Touceda, *Journal* of the Society of Automotive Engineers, Vol. 10, Page 53.

The article is primarily intended for the purchasing agent and the structural engineer. The difficulties encountered in the foundry, such as gating and pattern design, are discussed. The sources of trouble in machining malleable castings are outlined. Figures are given on the tensile properties of malleable iron and the characteristics of its chief ferrous competitors are covered briefly.

FORGING PROBLEMS

HISTORICAL SKETCH OF DEVELOPMENT OF FORGING. By S. L. Goodale and R. H. McMillan, *Forging and Heat Treating*, Vol. 8, Page 23.

A very general discussion of the development of the forging hammer is given.

DIE BLOCKS AS SEEN BY THE DROP FORGE PLANT. By A. A. Blue, *Forging and Heat Treating*, Vol. 8, Page 34.

The qualities desired in die blocks are reviewed and present die block practice is discussed. It is suggested that the die block situation would be greatly improved through the use of specifications on composition and physical properties, standardization of sizes, limits of tolerance, etc.

MAKING THE LATROBE HIGH SPEED TWIST DRILL. By S. A. Hand. *American Machinist*, Vol. 56, Page 246.

In making a 1⅛-inch drill an 8-inch ingot is cogged down to a 2-inch square from which the drill blanks are rolled out in seven passes. The blanks are carefully annealed previous to the twisting and machining operations. After machining and before attaching the sockets, the drills are quenched in oil from 2500 degrees Fahr. and drawn at 1100 degrees Fahr.

METALLOGRAPHY AND HARDNESS THEORY

THE SLIP INTERFERENCE THEORY OF THE HARDENING OF METALS. By Zay Jeffries and R. S. Archer, *Chemical and Metallurgical Engineering*, Vol. 26, Page 249.

A general reply is made to the various comments published since the original presentation of the theory. Present allotropic theories of hardening must be discarded since martensite is shown to be made up of alpha iron.

THE COLLOIDAL STATE IN METALS AND ALLOYS—IRON AND STEEL. By J. Alexander, *Chemical and Metallurgical Engineering*, Vol. 26, Page 201.

Beta iron is accounted for by assuming it to be alpha iron containing colloidally dispersed gamma iron. The metallographic constituents are discussed from the standpoint of colloidal solutions. Some consideration is also given to the hardness of colloids.

GRAIN GROWTH AND RECRYSTALLIZATION IN METALS. 1. DEFINITIONS. By Zay Jeffries and R. S. Archer, *Chemical and Metallurgical Engineering*, Vol. 26, Page 343.

Recrystallization is defined and a list of recrystallization temperatures are given. Methods of measuring grain size are presented and discussed.

REVIEW OF IRON AND STEEL LITERATURE FOR 1921. By E. H. McClelland, *Forging and Heat Treating*, Vol. 8, Page 4.

A list is given of articles and books on metallurgy, foundry practice, heat treatment, etc., published during the year.

THEORY OF THE HEAT TREATMENT OF STEEL. By W. M. Mitchell. *Forging and Heat Treating*, Vol. 8, Page 52.

The nature of steel is briefly discussed and the significance of the critical points is considered. The constitution of steels of various carbon contents is described and illustrated with photomicrographs.

THE X-RAY IN METAL ANALYSIS. From a paper by Dr. R. Schenck. *Iron Age*, Vol. 109, Page 531.

Heycock and Neville first used X-rays in the examination of alloys some 20 years ago. Their investigations were made on gold sodium alloys, whose constituents possessed great difference in opacity to X-rays. Plain carbon, and nickel, manganese and chromium alloy steels cannot be investigated in the above manner in that the constituents are of nearly equal opacity. Tungsten steels can be analyzed by this method, it being possible to obtain the tungsten content of the steel very accurately from the photographs. The more recent investigations in the X-ray examination of metals have been on the nature of the atomic constitution and were inspired by the ideas of von Laue.

THE STUDY OF COALESCENCE IN STEELS AND ITS COMMERCIAL RESULTS. By A. Portevin and V. Bernard, *Engineering*, Vol. 63, Pages 28-31 and 59-61.

For a given steel the factors which govern the amount of coalescence of the cementite above the A_1 range are: (a) Rate of cooling; (b) temperature and duration of initial heating; and (c) temperature alternations above A_1. The factors governing coalescence below the A_1 range are: (a) Temperature and duration of maintenance at this temperature; (b) previous mechanical treatment; (c) previous heat treatment. The carbon content and the presence of many alloying elements influence the coalescence in any group of steels. Changing the cementite of a steel from the lamellar to the globular form reduces the hardness about 50 per cent. Globular cementite reacts much more slowly to heat treatment than does the lamellar form.

NITROGEN IN STEEL

THE DETERMINATION OF NITROGEN IN STEEL. By F. Hurum and H. Fay, *Chemical and Metallurgical Engineering*, Vol. 26, Page 218.

The literature on the subject was consulted and of the methods found the iodide-iodate method, first reported by Grabe and Petren, was selected as the most practical. Five grams of steel are dissolved in HCl in a special container, a $NaOH$-$KMnO_4$ solution is added and the ammonia formed is distilled into H_2SO_4. The excess H_2SO_4 is determined by the iodide-iodate method. Specific directions are given for preparing the reagents and making the determinations.

WELDING

IMPORTANCE OF MANAGERIAL UNDERSTANDING OF WELDING. By G. O. Carter, *Iron Age*, Vol. 109, Page 323.

Welding has many applications in the steel industry, but the developments of its use have largely been left to the individual workman or to a foreman. Managers are just beginning to appreciate its possibilities. Methods of checking the ability of welders are given, together with some of the prominent uses.

WELDING RODS FOR OXYACETYLENE WELDING. By J. R. Dawson. *Iron Age*, Vol. 109, Page 468.

The welding of carbon and high speed steel, cast iron and nonferrous products, is considered and the selection of the proper welding rod for each case is discussed. It has been found that some batches of steel will not weld properly, even though chemical and metallographic examination revealed nothing out of the way. The article is illustrated with numerous photomicrographs.

NEW MEMBERS' ADDRESSES OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A represents Associate Member; S represents Sustaining Member; J. represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective

NEW MEMBERS

ADAMS, J. N., (M-10), Standard Oil Co., Richmond, Cal.
ANDERSON, H., (M-3), Mahr Mfg. Co., Minneapolis, Minn.
ANDREWS, J. L., (M-3), 6078 Northfield Ave., Detroit, Michigan.
BOLDUC, E. W., (M-2), 50 Mills St., Bristol, Conn.
BROOKS, W. C., (A-4), P. O. Box 447, Worcester, Mass.
COLONIAL STEEL CO., (S-3), Keystone Bldg., Pittsburgh, Pa.
COOK, F. H., (A-2), Crucible Steel Co. of America, Philadelphia, Pa.
COOLIDGE, R. H., (M-3), U. S. Ball Bearing Co., Chicago, Ill.
FERRY, O. N., (M-3), 111 Coniston Ave., Waterbury, Conn.
FIRTH STERLING STEEL CO., (S-2), McKeesport, Pa.
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GUNN, F. R., (M-3), 2313 W. Atlantic St., Philadelphia, Pa.
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HORTVET, R. M., (M-3), Mahr Mfg. Co., Minneapolis, Minn.
HUGHES, E. T., (M-2), 369 Beaver St., Beaver, Pa.
JACOBSON, H. W., (M-3), Gould & Eberhardt, Newark, N. J.
JOHNSON, W. R., (Jr.-3), 200 Knapp St. Apt. 3, Milwaukee, Wis.
JONES, H. I. (M-3), 654 Pearl Pl., Elmira, N. Y.
KELLEY, J. E., (A-3), Simonds Mfg. Co., Fitchburg, Mass.
KRAUSE, A. E., (M-3), 23 Wall St., Bethlehem, Pa.
KUMMER, R., (A-2), 469 Elliott Ave., Cincinnati, Ohio.
LARSON, C. L., (M-12), 23 Lakewood St., Worcester, Mass.
LARSON, P. A., (M-3), 17 Ekman St., Worcester, Mass.
LYONS, T. G., (M-2), 855 Cornwall St., Philadelphia, Pa.
MAIER, E. J., (M-2), 6545 Van Dyke St., Tacony, Philadelphia, Pa.
McCALLEN, T. P., (M-3), 311 Mayran Ave., Pittsburgh, Pa.
MILLER, C. C., (M-3), 2427 4th St., Minneapolis, Minn.
MILLER, J. R., (S-3), Jones & Laughlin Steel Co., Pittsburgh, Pa.
MINUSE, A. W., (A-4), Room 1027, 165 Broadway, New York City.
MORAN, J. J., (Jr-3), 166 E. 88th St., New York City.
MORRILLON, E. E., (M-12), 202 Miley Ave., Indianapolis, Ind.
MURDO, E. E., (M-2), Park Mfg. Co., St. Paul, Minn.
NOVAK, A., (M-3), 9114 Kennedye Ave., Cleveland, Ohio.
NUTTAL, R. D. CO., (S-3), Pittsburgh, Pa.
PATERSON, J. A., (M-3), 4 S. Buffum St., Worcester, Mass.
PFLUEGER, J. E., (M-3), Enterprise Mfg. Co., Akron, Ohio.
PITTSBURGH VALVE FDRY & CONSTRUCTION CO., (S-3), Pittsburgh, Pa.
PRATT, JONATHAN, (Jr-3), 99 Miserole Ave., Brooklyn, N. Y.
REA, J. C., (S-3), Oliver Iron & Steel Co., Pittsburgh, Pa.
RIDDLE, F. C., (M-2), 419 College Ave., Oakmont, Pa.
ROTHERHAM, G. C., (M-2), 6609 Hegerman St., Tacony, Phil., Pa.
SCHWENTLER, F. E., (M-3), 1932 N. Broadway, St. Louis, Mo.
SCIENTIFIC MATERIALS CO., (S-3), 717 Forbes St., Pittsburgh, Pa.
SCOTT, HOWARD, (M-3), 3825 14th St., Washington, D. C.
SHEFFIELD PUBLIC LIBRARY, (S-12), Surrey St., Sheffield, England.
SMUCK, JAMES, (M-10), Croix (Nord) France.
SNYDER, Q. S., (S-3), 41st & Willow Sts., Pittsburgh, Pa.
SQUIRES, A. J., (A-3), Somerville, N. J.
TENNESSEE COAL, IRON & RAILROAD CO., (S-10), Birmingham, Ala.
TRAEGER, A., (S-3), E. Leitz, Ltd., 60 E. 10th St., New York City.
TICHY, V. L., (M-3), 3178 W. 56th St., Cleveland, Ohio.

TRAPP, A. J., (M-3), 106 Oak St., Southington, Conn.
TRUMBORE, H. C., (M-3), Doehler Die Castings Co., Toledo, Ohio.
UHL, RAYMOND, (M-3), 6337 Torresdale Ave., Tacony, Philadelphia, Pa.
UNDERWOOD, W. A., (M-1), 775 Southbridge St., Worcester, Mass.
UNION STEEL CASTING CO., (S-3), Pittsburgh, Pa.
UNITED ENGINEERING & FOUNDRY CO., (S-3), Pittsburgh, Pa.
VANADIUM CORP. OF AMERICA, (S-4), Bridgeville, Pa.
VULCAN CRUCIBLE STEEL CO., (S-3), Aliquippa, Pa.
WALLEY, W. H., (M-3), 2519 Washington St., Minneapolis, Minn.
WEILAND, W. F., (M-3), 1237 Rebecca Ave., Wilkinsburg, Pa.
WILLIAMS, H. R., (A-2), Electric Alloy Steel Co., Philadelphia, Pa.
WRIGHT, F. G., (M-1), 1518 Euclid West, Detroit, Michigan.

CHANGES OF ADDRESS

BARDWELL, J. P.—from E. T. Ward Sons, New York City to 1834 77th St., Brooklyn, N. Y.
BERRYMAN, H. H.—from Pheoll Mfg. Co. to 1525 S. 57th Ct., Chicago, Ill.
BRADFORD, J. F.—from 1916 West Blvd. to 1906 E. 84th St., Cleveland, O.
BROOKS, C. A.—from 1393 Broadway, Rensslair, N. Y. to 100 Colonial St., Albany, N. Y.
BURGDUFF, H. M.—from 12 Mattie St., Auburn, N. Y. to Clayville, N. Y.
BUSH, A. T.—from 1414 Kanawah, Charleston, W. Va., to 109 S. Hill St., Massillon, O.
CASSIDY, A. G.—from 27 Banks St., Waltham, Mass. to 526 5th Ave., N. St. Petersburg, Fla.
CINIOTTI, G. E.—from 1021 Park Bldg. to 726 North Beatty St., Pittsburgh.
COPE, L. S.—from 920 Mary St., Ann Arbor, Mich. to National Screw & Tack Company, Cleveland, Ohio.
CUNNICK, P. C.—from 2807 E. Locust St. to 141 Forest Rd., Davenport, Ia.
DALTON, J.—from 206 Broad St., Charleston, W. Va., to 50 Elmhurst Ave., Elmhurst, N. Y.
DAVIS, G. F.—from 206 Broad St., Charleston, W. Va., to Bowling Green, Mo.
FULLMORE, H. W.—from 23 Curry St., S. Charleston, W. Va. to 151 E. Durham St., Mt. Airy, Philadelphia, Pa.
GARDNER, V. W.—from 531 E. 105th St. to 13706 Blenheim Rd., Cleveland, O.
GORDON, W. R.—from 985 Dewey Ave., Rochester, N. Y. to 33 Crescent Ave., Irondequot, N. Y.
GOSZTONYI, V. A.—from 3 Curry St., S. Charleston, W. Va. to 536 E. 3rd St., Bethlehem, Pa.
GRAHAM, A. K.—from Kirk-Latty Co. to 1619 Marlowe Ave., Lakewood, Ohio.
GRIFFITH, E. M.—from P. O. Box 75, Pittsburgh, Pa. to Universal Steel Co., Bridgeville, Pa.
GUNTERT, E. E.—from 505 Cutler Bldg., to 219 Post Ave., Rochester, N. Y.
HICKOX, DELOS—from Splitdorf Elec. Co. to 368 High St., Newark, N. J.
JOHNSTON, R. L.—from Acme Die Casting Corp. to Aluminum Die Casting Co., Brooklyn, N. Y.
LEDEBUR, G. A.—from 1102 E. 6th St. to General Elec. Co., Erie, Pa.
McDONOUGH, WM. D.—from Box 464, S. Charleston, W. Va. to R.F.D. No. 2, Reading, Pa.
McQUAID, H. W.—from Timken Roller Bearing Co. to P. O. Box 432, Canton, O.
MILLER, B. B.—from 5821 Pennsylvania Ave. to 5085 Iroquois, Detroit, Mich.
MITCHELL, W. M.—from 209 Kent Rd., Wynnewood, Pa. to 112 N. 34th St., Philadelphia, Pa.
NICHOLS, W. H.—from 44 Woerd Ave., Waltham, Mass. to Box 41 P.A.E., Exeter, N. H.
NORTH, J. H.—from Hawkridge Bros. Co., to Boston Athletic Assoc., Exeter St., Boston, Mass.
NORTON, O. G.—from Zenith Carburetor Co. to Henry Clay Hotel, Detroit.
OMALIA, JAMES—from 114 7th Ave., S. Charleston, W. Va. to Midland, Pa.
PFEIFFER, C. B.—from 2691 E. Jefferson Ave., Detroit, Mich. to Kirchen Machine & Tool Co., Lansing, Mich.
POLHEMUS, G. J.—from Ludlum Steel Co. to 1238 W. Washington Blvd., Chicago.

PUTNAM, A. H.—from 1710 E. 12th St. to 410 Perry Apts., Davenport, Iowa.
QUICK, G. W.—from Bureau of Standards, Washington, D. C. to Claredon, Va.
ROBERTS, J. H.—from Midvale Steel Ordnance Co., Philadelphia, Pa. to Electric Alloy Steel Co., Youngstown, Ohio.
ROHM, F. G.—from Universal Steel Co. to R. D. No. 3, Bridgeville, Pa.
ROOT, O. J.—from Root & Van Der Voort Eng. Co., E. Moline, Ill., to Eagle Rock, Calif.
STAMP, W. R.—from France Fire Eng. Co. to 828 Cedar Ave., Elmira, N. Y.
STENGER, E. P.—from 512 Park Ave., Harrison, O. to 3110 Imperial Ave., Cincinnati, O.
SYKES, C. J.—from H. G. Saal Co. to 2132 Lawrence Ave., Chicago, Ill.
TORSELL, C. T.—from 112 Dickey Ave. to Warren Iron & Steel Co., Warren, O.
TOWNE, T.—from 12 Platt St. to 32 W. 40th St., New York City.
WILLIS, R. E.—from 1401 David Whitney Bldg. to 6040 Woodward Ave., Detroit.
WOODWARD, A. F.—from 827 Main St., Charleston, W. Va., to 432 Hawkins St., Cincinnati, O.
YOUNGBLOOD, F. J.—from 755 Marlyn Rd. to 1317 Spruce St., Philadelphia, Pa.

MAIL RETURNED

BILLINGSLEY, J., 23 Euclid Avenue, Detroit, Mich.
BOYER, S. H., Studebaker Corporation, Detroit, Mich.
HOLLANDER, J. A. 459 Lawn Avenue, Cincinnati, Ohio.
MARRAN, JOHN S., 32 Rowsley St., Bridgeport, Conn.
PIERCE, FRED, (M-4), 2801 La Salle St., St. Louis, Mo.
TUEBER, CHAS. F., 1229 S. State St., Chicago, Ill.

News of the Chapters

SCHEDULE OF REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list should communicate with the National Office in order that the list may be as complete as possible.

Charleston—First Tuesday, Kanawah Hotel, 8 p. m.

Chicago—Second Thursday, City Club, dinner 6:30 p. m., meeting 8 p. m.

Hartford—Thursday nearest 10th of month, Jewell Hall, Y. M. C. A., 7:45 p. m.

New York—Third Wednesday, Merchants Association of New York, Woolworth Building.

Pittsburgh—First Tuesday, Chatham Hotel, dinner 6:30 p. m., meeting 8 p. m.

Rockford—Second Monday, Nelson Hotel.

Rochester—Second Wednesday.

Schenectady—Third Tuesday, Civil Engineering Bldg., Union College.

Tri City—First Thursday following first Monday.

Washington—Second Friday.

TO THE MEMBERS OF ALL CHAPTERS AND ESPECIALLY TO THE MEMBERS OF ALL MEMBERSHIP COMMITTEES

D. H. Horne

GREETINGS: Permit us to introduce to you Mr. D. H. Horne, otherwise known as "Bert", who in his spare time represents the Standard Alloys Co. of Pittsburgh, and who has solved the mystery, if one ever existed, of how to secure Sustaining Memberships.

Not very long ago the Pittsburgh Chapter decided it needed a chairman of its Finance Committee who possessed the happy faculty of being able to increase the exchequer of the local chapter without making inroads upon his own personal bank account; further it was deemed advisable that inasmuch as a Sectional Meeting of the National Society was to be held in Pittsburgh on May 25 and 26 there should be a treasurer of the Finance Committee whose prerogative it would be to pay whatever expenses might be incurred by

the local chapter in extending true Pittsburgh hospitality to the visiting members and guests. Consequently Mr. Horne was honored with the appointment of Chairman of the Finance Committee, but he immediately discovered that he was chairman of a committee that did not have an excessive amount of the where-with-all used in eradicating financial indebtedness.

"Bert" thought it advisable that his committee should be something other than one in name only and set about to prepare to meet future emergencies. The best plan that presented itself to the capable chairman was that of increasing the number of sustaining members of the Pittsburgh Chapter and thus obtain the increased revenue afforded to the local chapters by a recent ruling of the Board of Directors of the A. S. S. T. at their New York meeting which permits the local chapter to retain practically 75 per cent of the revenue provided from this class of membership.

Once a plan of action had been decided upon "Bert" got busy immediately, made several calls, wrote some letters and began to send in applications for sustaining memberships. The result of his activities during the past month brought 22 new sustaining members to the local chapter, as are listed under 'Sustaining Members' on page 23 of Transactions.

The Finance Committee no longer has cause to worry about the incurring of expenses for the Sectional Meeting as the Chairman of the Committee has solved the problem for them to their great satisfaction and admiration.

The activity of Mr. Horne is but an indication of what all the other chapters may do, providing a little thought, concentration and effort are given to the subject of Sustaining Memberships. All that was necessary in order to interest the manufacturing industries of the Pittsburgh district as to the desirability of supporting the local chaper and the National Society in their educational work was to have the matter presented to them for their consideration.

"Bert" has set the pace and is perfectly willing to give any information that any chapter may wish with reference to the "How" of his success and because of his great interest in the Society would be pleased to have anyone exceed his record of 22 sustaining memberships in one month.

HOW HIGH DOES YOUR CHAPTER STAND?

BELOW is printed the standing of your chapter with reference to the number of members it has. This list was compiled as of March 1. A new list will be published in the next issue of TRANSACTIONS with the standing as of April 1.

A very small amount of concentrated effort in securing new members will materially advance the position of your chapter as a large number of them are separated but by a few members only. Particular attention is called to the first six—the positions of Chicago, Detroit, Philadelphia, Cleveland, Pittsburgh and New York can easily be changed as they all have very close to the same number of members, so any special activity is sure to cause a rearrangement of their rank.

For increase of membership, Rockford has made a very commendable showing inasmuch as it was organized last December and since that time

has passed many of the older chapters until at the present it ranks in the fourteenth place.

Your interest in your chapter should be so strong that you should lend every endeavor to acquaint those who are or should be interested in the Society with the benefits of membership so that your chapter may take its proper position among the other chapters of the Society.

Following is the rank of the chapters on March 1:

1. Chicago	11. Lehigh Valley	21. Providence
2. Detroit	12. Milwaukee	22. Schenectady
3. Philadelphia	13. North West	23. New Haven
4. Cleveland	14. Rockford	24. Washington
5. Pittsburgh	15. Cincinnati	25. Buffalo
6. New York	16. Tri City	26. Toronto
7. Indianapolis	17. St. Louis	27. South Bend
8. Hartford	18. Charleston	28. Rochester
9. Syracuse	19. Springfield	29. Bridgeport
10. Boston	20. Worcester	30. Gary

PHILADELPHIA CHAPTER

The Philadelphia Chapter held one of its largest and most enthusiastic meetings on Friday evening, Feb. 24. This was the second annual "Big meeting," and it really was big, both from the standpoint of numbers and the high character of the addresses. A dinner in the Engineers Club, preceded the meeting, and was served to 52 members and guests. Later, when Chairman A. W. F. Green called for order, there were about 225 persons present to hear the fine program arranged for the meeting. The Chapter established the custom last year, of making a special occasion of the visit of the President of the Society.

President F. P. Gilligan gave a most interesting paper, entitled, "Quality First in Material and Workmanship", illustrated in such a way as to bring out very clearly the salient points. This was the first opportunity the Chapter has had of meeting the National President, and they voiced their approval in no uncertain terms.

The meeting was particularly honored by the presence of Harry Brearley, of Sheffield, England, who was the guest of T. H. Nelson, general steel works manager of Henry Disston & Sons, Inc. Mr. Nelson also came from Sheffield. Mr. Brearley's name had been very prominently mentioned at the Chapter's January meeting by H. J. Stagg, thus the audience was anxious to hear him. While he said he had not come to talk, he made some interesting comments on President Gilligan's paper.

The Chapter's persistent efforts finally resulted in Dr. Mathews succumbing, and he gave an address entitled "What Is Steel"? His presentation of the subject was most scholarly. There are few men who know the answer to the question in his title, as well as Doctor Mathews, who is president of the Crucible Steel Co. of America. Both President Gilligan's and Dr. Mathews' papers will appear in a later issue of the TRANSACTIONS.

All business men in the vicinity of Philadelphia have a high regard for Richard Spillane, editor of the business section of the Philadelphia Publc Dedger. Mr. Spillane recently completed a national tour which brought him in contact with the leading industrialists of the country. He gave his views on the present situation in a highly entertaining and instructive manner. His remarks will be found elsewhere in this issue.

Any one of the speakers would have been a sufficient attraction, and

when there were four men of such caliber, it is not hard to find the reason for a large attendance. Among the guests were men from as far west as Altoona, as far south as Wilmington, and as far north as New York. The Lehigh Valley Chapter was represented by A. P. Spooner. This "Big Meeting" will be long remembered.

The Chapter's Membership Committee, under the guidance of George Richardson, has been working on a plan that has so far resulted in the addition of 17 new members. This has been accomplished largely through individual effort, supplemented by form letters, personally addressed and signed. Due to the fact that business conditions might be better, it is necessary to use different sales methods to obtain new members. President Gilligan, in his conference with the Executive Committee, before the meeting, emphasized the idea of applying a steady pressure rather than an intensive campaign. He stated that last year the Society had a growth of 18 per cent and he hoped that it could do as well this year.

The next meeting of the Chapter was on March 31 at the Engineers Club, at which time A. H. d'Arcambal gave an illustrated talk on "High Speed Steel". Mr. d'Arcambal is metallurgist of Pratt & Whitney Co., Hartford, Conn., and is an authority on the subject. E. H. Barker, of A. H. Wirz Co., Chester, Pa., also gave a paper on the "Local Hardening of Extruding Dies". This talk was scheduled for the January meeting but due to the lack of time after H. J. Stagg's paper, it had to be postponed.

ROCHESTER CHAPTER

S. W. Miller, president of the Rochester Welding Works, addressed the March meeting of the chapter which was held at the Engineers' Club on March 23. The subject of Mr. Miller's interesting paper was "Non-metallic Impurities in Steel." Mr. Miller has a nation wide reputation for very excellent research work that he had done, and the local members felt very much pleased to have had Mr. Miller address them.

CINCINNATI CHAPTER

The regular March meeting of the Cincinnati Chapter was held on Friday, March 24, at the Ohio Mechanics Institute. Dr. J. Culver Hartzell presented an interesting paper on "The Crystallography of Iron, Its Fundamental Relation to Steels and Their Heat Treatment." In his address Dr. Hartzell gave some of the fundamentals of the crystallization of iron and steel. He also enlightened the members of the chapter on liquid and solid solutions and the effect of impurities in iron, the effect of heat treatment and the cause of fracture in steels.

SPRINGFIELD CHAPTER

The Springfield Chapter held its March meeting on Friday evening March 24 at the Chamber of Commerce building. The speaker of the evening was F. P. Gilligan of the Henry Souther Engineering Co., Hartford, and President of the Society who gave a talk on "What Happens to Steel When You Heat and Quench It". The talk was illustrated with a number of lantern slides showing the change in microstructure resulting from various treatments, photographs of actual pieces which failed in service through faulty treatment or material, methods of inspection, effect of various treatments recommended by the S. A. E. for carburized material, etc. The meeting was very largely attended and everyone enjoyed Mr. Gilligan's instructive presentation of the subject.

DETROIT CHAPTER

The first March meeting of the Detroit Chapter was held at the Board of Commerce on March 13. H. G. Freeland, metallurgist of the Hoover Steel Ball Co., Ann Arbor, Mich., presented a paper on "Ball Steel", treating the subject from the standpoint of the ball manufacturer including the inspection of the steel and the various stages of its fabrication. Mr. Freeland is a recognized authority on ball steel and his paper will be published in an early issue of the TRANSACTIONS together with the interesting discussion that took place at the meeting.

The second meeting of the month was held at the Elks' Club, on March 29 when an invitation was accepted by the chapter to be present and hear Charles E. Carpenter, of Philadelphia, who presented a talk on "Individualism vs. Socialism". Mr. Carpenter's reputation as a rapid fire speaker had preceded him and the turn-out that greeted him was a fine compliment to Mr. Carpenter and proved to be a worth while meeting.

NEW HAVEN CHAPTER

About 175 members and guests attended the meeting of the New Haven chapter on Wednesday evening, March 1 at the Geometric Tool Co. The excellent heat treating department of this company was in full operation and a practical demonstration took place under the direction of Major A. E. Bellis. Following the demonstration Frank P. Gilligan and W. H. Eisenman, National Secretary, addressed the members with reference to the "Activities of the Society", while Mr. Gilligan presented an illustrated paper on "Tool Steel" that was very favorably received. As an added attraction H. G. Hall, of R. Wallace & Sons Mfg. Co., presented his paper on "Stainless Steel" which he delivered before the New York Sectional meeting. Harry Brearley, of Sheffield, England, inventor of stainless steel, was present at the meeting.

NORTH WEST CHAPTER

The fifth lecture in the Educational Course being conducted by the Steel Treaters' Section, which is the Northwest Chapter of the American Society for Steel Treating, was held at the Club rooms Tuesday evening, Feb. 28. Dinner was served as usual at 6:30, and the business meeting commenced at 7:30. The subjects for the evening were "Malleable Iron, Its Production, Properties and Uses," by Sidney Horsley, superintendent of the Northern Malleable Iron Works, of St. Paul, and "Furnaces," by W. E. Johnston, Mahr Mfg. Co. This meeting followed closely the carefully thought out program for the course of lectures, so that the various topics are being developed as prearranged. Chairman O. E. Harder and the Executive Committee have been unusually successful in presenting a program which meets the requirements of the man who has had a technical education as well as the man whose experience is limited solely to his daily work in the shop. The briefs that are furnished with the lectures supply the members with a permanent record of each subject, so that at the close of the course they will have quite a voluminous file of educational matter of real value.

The regular meeting of this section, which would ordinarily have been held about the middle of March was postponed until Tuesday, March 28, when a joint meeting was held with the members of the Educational Course. The Executive Committee was fortunate in prevailing upon Prof. John F. Keller, president of Louis Institute, Chicago, to attend this

meeting and speak on the subject of "Forgings." As he was contemplating a visit to Milwaukee and later to Davenport, it required but little urging to induce him to include this city in his intinerary.

Mr. Keller has been trained in the mysteries of steel treating from a blacksmith, and is now one of the recognized authorities. He is a man who has had many years of active experience at the forge before taking up his technical studies, so that he possesses both a practical and a theoretical knowledge of the subject. He was professor of forging at Purdue University for fifteen years. He is past president of the Steel Treating Research Society, and as stated is now president of the Louis Institute of Chicago.

Dr. Charles A. Prosser, director of Dunwoody Institute, also addressed the members at this meeting on the subject of "Professional Spirit Among Steel Treaters."

PITTSBURGH CHAPTER

D. K. Bullens, of Philadelphia, addressed the Pittsburgh Chapter of the American Society for Steel Treating at its regular meeting on March 7. This meeting was held in the auditorium of the Bureau of Mines and the dinner preceding the meeting was attended by probably 80 members and guests. The total attendance for the lecture was well over 100. Mr. Bullens particularly stressed the human element factor in heating operations and the "One In and One Out", as he termed it, principally of securing continuous and uniformly heated parts.

Plans for the sectional meeting of the Society in Pittsburgh, May 25 and 26, are progressing very nicely as developed at the meeting of the Council on March 16. Probably one of the most encouraging bits of information received was that the Pittsburgh Chapter, through the efforts of D. H. Horne, has secured 22 new sustaining memberships.

At this council meeting T. D. Lynch, Westinghouse Electric & Mfg. Co., discussed the proposed standards specifications for the Society which the Standards Committee of the National Organization, of which he is chairman, is developing.

HARTFORD CHAPTER

The March meeting of the Hartford Chapter was held on March 9. The audience consisted of 90 members and guests. Among the visitors from other chapters and distant cities were Mr. Wedlake, of the Wilson-Maeulen Co., E. M. Converse, of the Dearborn Chemical Co., G. R. Brophy, of the General Electric Co., and Mr. Malone, of the Calorizing Co., of Pittsburgh. They were introduced to the audience together with four new members of the chapter, R. C. Baldwin of the Stanley Rule and Level Co., O. N. Ferry of the Waterbury Tool Co., A. G. Trapp of the Peck, Stowe, and Wilcox Co., and T. H. Platt of the Dearborn Chemical Co

G. R. Brophy gave an interesting talk on the subject of "Calite". His talk was based largely on his paper which appeared in the February TRANSACTIONS, but was new to many of those present and gave an opportunity for discussion by those who were unable to attend the New York Sectional meeting where the paper was first delivered.

The samples returned by competitors in the heat treatment contest were next exhibited, and the scleroscope and Rockwell hardness were determined on each in the meeting room. Owing to the large number of

tests which had to be made, it was not possible to finish the rating of each competitor. The final results and the winner of the prize, however, will be announced at the next meeting. If possible, the contest committee will tabulate the data obtained from the various tests, for publication at some future date.

The great variation in results obtained by the different competitors illustrated clearly that heat treatment is not a hit or miss proposition, but that success in obtaining desired physical properties requires close adherence to scientific methods. It was observed that the best results were obtained on chrome and nickel-chrome steels when a double treatment, that is, a normalizing quench plus a hardening quench, was applied. Double treatment also produced best refinement of the core in case hardened samples.

O. N. Ferry exhibited a cylinder barrel of a hydraulic variable speed gear, which was a small size replica of a 600-pound barrel used in controlling the speed of warships. On the 600-pound size, some difficulty was experienced in obtaining the desired hardness on case inner surfaces, which were required to be glass hard. High pressure jets of the quenching liquid were suggested, the jets to play in each hole of the carburized forging, also against the port face. It was also suggested that soft spots might be due to cementite networks produced by carburizing at an excessively high temperature. A temperature not in excess of 1650 degrees Fahr. was recommended for the carburizing operation.

As a matter of interest in connection with the heat treatment contest, one of the chapter members has discovered a new carburizing compound. His sample was exhibited at the meeting, and attention was called to the very fine case which was observed when the specimen was fractured. The audience was invited to try its luck at guessing the nature of the carburizing compound used. One guesser suggested that he had raided the barnyard, but it developed that it was really the hen coop that furnished the packing material.

ROCKFORD CHAPTER

The regular meeting of the chapter on Feb. 13 was held after the usual informal supper at the Nelson hotel. There were about 75 members present to hear National President F. P. Gilligan talk on "The Influence of Quality and of Workmanship on Material". Just preceding the address of President Gilligan, Mr. Birtchey, a guest, told the chapter something of his newly patented carburizing process which he hopes will be a time, labor and money saver for carburizers. He exhibited some interesting test pieces taken from a run made by Prof. J. F. Keller at Lewis Institute, Chicago.

President Gilligan was then introduced by Chairman Muehlemeyer and presented his very interesting paper. In the discussion which followed, high speed steel and grinding were the topics.

The regular March meeting of the Rockford Chapter was held on March 13 at the Nelson hotel. After an informal dinner the meeting was called to order at 8 p. m. The speaker of the evening was R. M. Smith, Mechanics Machine Co. and secretary of the chapter who chose "Pyrometers" as his subject. A lively discussion followed, and an enjoyable evening was spent by the large number in attendance.

WORCESTER CHAPTER

The February meeting was held in the assembly room of the Boy's Trade School on Feb. 28. C. A. McCune, welding engineer of the Paige

Steel & Wire Co., Bridgeport, lectured and showed an interesting moving picture film on "The Manufacture of Armco Ingot Iron, Welding Rods, and Electrodes". Mr. McCune showed samples of welding iron and made a thorough discussion of the entire subject. The National Secretary, W. H. Eisenman, was presented and outlined briefly the progress of the Society during the past year.

The annual meeting of the Worcester Chapter was held March 20 when President F. P. Gilligan, Dr. J. A. Mathews and Neil O'Hara were present and afforded the members a very profitable and interesting evening. The remarks of Chairman V. E. Hillman were as follows:

"Next month marks the anniversary of the Worcester Chapter. The idea of creating such an organization was conceived in the mind of my esteemed associate, Mr. Rogers. In fact, he has rendered invaluable aid in fostering the activities of the Society. His wide acquaintance in the steel industry, his association with men of affairs, and the contagious nature of his enthusiasm are intimately interwoven with the success of the Chapter.

"I wish to acknowledge my appreciation of the work accomplished by the Executive Committee. They made a generous contribution to the Chapter's early development. They offered material assistance in establishing its foundation. They tendered timely suggestions for furthering its objects. They responded to the call of the chairman. There was indeed, a genuine communion of interest among the handful of men who directed the affairs of the local chapter.

"The scope of the national organization is well known. Its aim is described as an educational movement to collect worth while ideas. Its deeper purpose, however, is to scatter, to extend, to circulate, 'that knowledge which does not guess, and skill of hand which does not err—these alone can turn waste into wealth and safeguard the standards of high efficiency.'

"Men of broad vision and foresight are in hearty accord with a project that diffuses ideas and interchanges experience and knowledge. The days of giant secrets are past, the mantle has been removed from industry, secrecy cast aside, egotism up-rooted, and self sufficiency has been displaced by a more sympathetic regard for the pursuits and passions of others.

"Two types of men may be in attendance at a chapter meeting; the parasite, who sucks sustenance from the brains of others and gives nothing in return, and the liberal mind who absorbs a fragment of knowledge and eagerly awaits the opportunity to impart an equal amount of intelligence to his fellow members. Current observation impells me to state that the Worcester Chapter is composed of men who belong to the generous minded class--men who are eager to rub elbows and exchange ideas for the betterment of their product. Guests who have been in attendance at our meetings have spoken of the quality of the discussions that usually follow the presentation of a paper.

"Admit, for so is the fact, that the local organization has been successful in its activities. We are now confronted with the responsibility of enlarging the framework that has been erected. This task may be accomplished readily by frequent elections. Your interest will be more secure, your society better governed, if you adopt the most simple and familiar portion of time applicable to an election, namely—one year. Where annual election ends, dissatisfaction begins. Every member should

familiarize himself with the activities of the Society. This information can best be obtained by holding office.

"Who should hold office? Any member whose merit may recommend him to the esteem and confidence of his associates; any member who possesses the capacity to discern and the ability to pursue the common good of the Chapter. He should be eligible for office. Wealth, station in life, professional standing, should not influence you in the choice of your officers. If the "Man at the Fire" is capable, elect him. Make the chapter democratic, the object of curiosity and conversation.

"I am eager to see the chapter advance, I am interested in its welfare. Hence, as retiring Chairman, I offer my remarks to the newly elected officers in a tentative manner."

The newly elected officers are: J. E. Rogers, chairman; and William Bacon, secretary-treasurer. The executive committee is composed of: G. C. McCormick, J. C. Spence, P. H. Knowles, and V. E. Hillman.

SYRACUSE CHAPTER

The March meeting of the Chapter was held at Yates hotel on March 4 and consisted of a round table discussion of troubles. It was not supposed that as many troubles existed in Syracuse as were presented at the meeting, however, each one brought forth a very interesting discussion and suggestions resulted for the elimination of the difficulties.

LEHIGH VALLEY CHAPTER

The Lehigh Valley Chapter held a fine meeting on March 14 when O. F. Luckenbach presented an exceptionally fine paper on "Drop Forgings" while B. F. Shepherd presented an equally interesting paper on "Carburizing". The meeting was held at the Easton Public Library and was very largely attended.

RHODE ISLAND CHAPTER

The Rhode Island Chapter held a meeting on Wednesday, March 8, at the Providence Engineering Society rooms when President F. P. Gilligan paid his annual visit to the chapter. About 100 were in attendance and highly appreciated Mr. Gilligan's exposition of his subject. A buffet luncheon and smokes were served at the close of the discussion.

MILWAUKEE CHAPTER

The Milwaukee Chapter held a very interesting meeting in the Hotel Medford on Monday evening, March 27, when Prof. J. F. Keller, of Lewis Institute, Chicago, spoke on the subject of "Why Steel Warps". Professor Keller had a number of interesting proofs with reference to the working of steel. A large audience greeted Professor Keller and felt highly repaid for their attendance. H. G. Lloyd, 611 Majestic building, has been elected Secretary-Treasurer of the Milwaukee Chapter. Mr. Lloyd brings to the office a wide acquaintanceship with the steel treating industry of this vicinity as well as a wide experience in secretarial duties. The Chapter is to be congratulated on Mr. Lloyd's acceptance of the position.

ST. LOUIS CHAPTER

The March meeting of the St. Louis chapter was held at the Engineers' Club on March 10. About 75 were present to see the motion picture films on the "Manufacture of American Tool Steel" through the courtesy of the Atlas Crucible Steel Co., Dunkirk, N. Y., but at the last

minute the film was damaged at the factory and could not be shown. The meeting was turned into a round table discussion of tool steels and heat treating problems and while there was considerable disappointment because of the failure of the films to arrive, nevertheless, the meeting proved to be very successful.

WASHINGTON CHAPTER

On March 22 one of the most interesting meetings of the year was held by the Washington Chapter, at which a general discussion of the selection, heat treatment, inspection and testing of automotive steels was carried on in the presence of about 40 to 50 members and guests. Beginning with the application, treatment and properties of various nickel-chromium steels and followed by an interesting presentation by one of the members of the chapter relating to characteristics of spring steels, the discussion finally turned to the question of gases in metals, melting practice and carburizing.

Among those who participated in various phases of the discussion were P. E. McKinney and Jerome Strauss, Washington Navy Yard; J. S. Vanick and H. J. French, Bureau of Standards; and W. H. Whitebeck, secretary-treasurer of the Charleston Chapter.

Preceding this very lively session, lasting for more than 2 hours, the usual dinner was held at the Harrington Hotel. These have become one of the interesting and important features of the regular meetings, and during the past 4 months there has been an average attendance of about 16.

Commercial Items of Interest

UNDER the joint sponsorship of the Grinding Wheel Manufacturers Association of the United States and Canada and the International Association of Industrial Accident Boards and Commissions, a sectional committee has been organized for formulating a safety code for abrasive wheels. The code prepared by this committee and approved by the sponsors has been approved as a tentative American standard by the American Engineering Standards Committee. The code contains rules and specifications considered necessary to insure safety in the use of abrasive wheels operating at speeds in excess of 2000 surface feet per minute. It consists of sections dealing with scope, types of protection devices, storage and inspection of wheels, general machine requirements, protection hoods, work rests, protection of wheels, flanges, mounting, speeds, operating rules and general data. It is well illustrated.

Copies of the code may be secured from the American Engineering Standards Committee, 29 West Thirty-ninth street, New York, at 10 cents each.

The Colonial Steel Co., Pittsburgh, has recently purchased ground at 2121 St. Clair avenue, Cleveland, and will erect at once a brick warehouse to be used for the storage and sale of the crucible and open-hearth tool steel made by that company. In addition, this warehouse will contain furnaces and equipment for heat treating steel with a view to assisting customers in working out problems of this kind and for investigating the best methods of treatment.

Burning Liquid Fuel is the title of a recent book by William Newton Best, published by the U. P. C. Book Co., Inc., New York. The selling price is $5.00. This book which has 342 pages, contains a wealth of material on burners, furnaces and various oil burning installations. It is a practical treatise on the perfect combustion of oils and tars, giving analyses, calorific values and heating temperatures of various gravities of fuel. Information is given on the design and proper installation of equipment for all classes of service. In an effort to make the volume as clear and simple as possible some 316 photographs and sketches are reproduced. Doctor Best is a pioneer in the development of liquid fuel and has followed its rapid expansion in recent years, thus he is recognized as an authority upon the subject.

The Bureau of Standards, Washington, is preparing a summary of the data obtained on the various carbon and alloy steels which have been tested in the metallurgical laboratories of the bureau. This summary will include the effects of normalizing rolled low carbon steel, the effects of 1.25 per cent of manganese, the presence of 5 per cent

cobalt, the addition of 0.4 per cent molybdenum to carbon-chromium steel, and the effect of various heat treatments on their properties. Progress has been made also in determining the effect of time annealing at blue heat on the properties of cold rolled boiler plate.

In pamphlet No. 168, recently issued by E. Leitz, Inc., New York, microscopes and pertinent equipment is described. This includes several types of lamps for illuminating the specimens. The manufacturer introduces a new research microscope equipped with the double eyepiece, thereby eliminating eye strain and fatigue.

Hugh M. Henton, formerly of Case School of Applied Science, Cleveland, has opened an office as consulting engineer in metallurgy and metallography, in the National City building, Cleveland.

The Surface Combustion Co., 366 Gerard avenue, New York, announces that it has ready for distribution Bulletin No. 3D on its low pressure air-gas inspirators. These inspirators are designed so as to be readily applicable to any make of gas furnace.

A new office has been opened at 1011 Majestic building, Milwaukee, by the Armstrong Cork & Insulation Co., Pittsburgh, with Hugh Krampe in charge. It will serve eastern Wisconsin and the upper peninsula of Michigan. The Denver office has been re-established at 1875 Gaylor street under Alex Callow.

James E. McKenny, for the past year superintendent of the Standard Spring Co., Cleveland, has resigned and returned to his former home in Worcester, Mass. Before going to Cleveland he was located in Youngstown, O. Mr. McKenny is a former superintendent of the National works of the Wickwire Spencer Steel Corp., Worcester, and at one time was production manager for the former Morgan Spring Co. of that city, now the Morgan works of the Wickwire Spencer Steel Corp.

Robert C. Stanley, formerly first vice president, recently has been elected president of the International Nickel Co., Bayonne, N. J. Mr. Stanley will effect a reorganization of personnel, involving as its chief feature a new department of development and research with headquarters at 67 Wall street, New York. This department will be under the direction of A. J. Wadhams, as manager and associated with him will be Dr. Paul D. Merica, director of research. Mr. Wadhams has been manager of the large Bayonne refinery of the company and has for years been in direct charge of the manufacture of the company's products.

F. G. Davis, who has represented the Atlas Crucible Steel Co. in the Detroit district for the past three years, has resigned effective April 1 to accept the position of district manager of sales in the Detroit district

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EMPLOYMENT SERVICE BUREAU

The employment service bureau is for all members of the Society. If you wish a position, your want ad will be printed at a charge of 50c each insertion in two issues of the Transactions.

This service is also for employers, whether you are members of the Society or not. If you will notify this department of the position you have open, your ad will be published at 50c per insertion in two issues of the Transactions. Fee must accompany copy.

Important Notice

In addressing answers to advertisements on these pages, a stamped envelope containing your letter should be sent to AMERICAN SOCIETY FOR STEEL TREATING, 4600 Prospect Ave., Cleveland, O. It will be forwarded to the proper destination. It is necessary that letters should contain stamps for forwarding.

POSITION WANTED

METALLURGIST—Chemist or Superintendent of Heat Treatment. Technical graduate. Extensive experience with some of the largest companies in the country, also steel mill experience. Heat treatment, tool hardening, annealing, pyrometry, chemical analysis, physical testing, metallography, magnet testing, tool testing, investigation of trouble and research. Age 26. Reasonable salary desired. Eastern location preferred. 4-15.

METALLURGIST or SUPT. HEAT TREATING—Technical graduate University of Illinois. Experience in heat treating and annealing forgings and castings all sizes up to 50 tons; production study and estimating; metallurgical, metallographic, chemical and physical testing, and final inspection; installation and maintenance various makes pyrometers; research and investigation. Three years superintendent heat treating. Age 30. Address 4-12.

ASSISTANT—METALLURGIST—Technical graduate. Specialized on Pyrometer maintenance and installation. Five years experience in heat treating department and laboratory of several large automobile parts manufacturing companies. Experienced in handling of men. (Write for detailed experience.) Location preferred Cleveland. Salary desired $175.00. Address 2-25

METALLURGIST—or Supt. of Heat Treating with 12 years experience, 10 of which have been as executive in charge of laboratories and supervisor of metallurgical operations in Steel Works and industrial plants. Broad experience in chemical, physical and metallographical testing and the heat treatment of automobile and other alloy steels. Location desired East of Pittsburg, age 30, married. Address 4-7.

SUPERVISOR HEAT TREATING, Chemical, Metallurgical, Metallographical Laboratory, large Motor Truck Company. 12 years experience. Formerly with U.S. Steel Corporation and Government Bureau of Tests & Metallurgist, also foundry experience in malleable, gray iron, steel, semi-steel. Age 35. American. Married. Eastern location preferred. Wages desired $200.00 per month. Answer 3-25.

FOREMAN OR INSTRUCTOR—Nine years instructor Forge Work, College Graduate (University four years) foreman toolsmith and steel treater of large ship-building corporation. Thoroughly experienced in all classes of steel. Wages reasonable. Location preferred Ohio, Massachusetts, New York, Pennsylvania, and Connecticut. 2-5

STEEL EXPERT—Heat treatment, metallurgy. A graduate in chemistry and iron and steel manufacture. Six years laboratory experience. Desire position in production department. Can make good. Present salary ($3000.00) Ordnance man, Navy Department. Will consider ($2000.00) as a start if there are good prospects. Address 3-10

CHEMIST OR HEAT TREATER—Technical graduate. Experience in chemical and physical testing, heat treating of steels, platinum metals and rare earths. Best of references. Reasonable salary. Address 3-15

CHEMIST OR ASSISTANT TO CHIEF METALLURGIST—Technically trained. Practically experienced in chemical and physical analysis, pyrometry, general heat treating, foundry control, shop work and methods. Able to investigate trouble and handle same. Michigan or adjacent territory preferred. Answer 3-20

TOOL HARDENER OR FOREMAN—20 years earnest effort in tool forging and tool hardening with extensive high speed steel experience. Can offer efficient operation or supervision. Exceptionally successful in eliminating scrap. Excellent references. Location immaterial, wages desired $50.00 per week. Address 3-40

SALES ENGINEER—Thorough metallurgical training and experienced salesman. At present employed but desires change. Wide acquaintance New York, New England and Canada. Basic knowledge foreign markets and can produce. Age 28. Married. Address 4-5

FOREMAN HEAT TREATMENT—16 Years experience on armor plate gun forgings and all kinds of heavy forgings including carburizing, research testing and experimental work including design operation and erection of all types of heat treating furnaces. Age 32. Married. Address 3-5

METALLURGIST—College graduate, at present metallurgist with prominent automotive concern, three years experience in general heat-treating, case hardening pyrometry, microscopic examination and chemical analysis. 2-10.

CHEMIST-METALLURGIST—Experienced in making steel castings, all processes. Also practical foundryman, steel blower, and chill roll maker. Have been Supt. of large foundry. Best of References. Age 40. Married. Address 3-2.

METALLURGIST OR CHEMIST—Graduate of Ohio State. Extensive experience covering heat treatment, case hardening, pyrometry, chemical analysis, metallography, and investigation of tool troubles. Best of recommendations. No preference as to location. Address: 4-30.

Was connected with United States Naval Ordnance Plant having charge of metallography and heat treatment the past two years, has had practical electric melting experience. Best of recommendations. No restrictions of location. Address 4-35.

FOREMAN: 30 years practical experience in heat treating, forging tool hardening, carbonizing. 5 years as foreman of heat treating. Location preferred in Pennsylvania, New Jersey, or Maryland. Salary desired $200 per month. Address 9-3.

HEAT TREATING DEPARTMENT—Technical graduate. Hardening room, automobile firm. Experienced on aluminum castings. Die Superintendent and metallurgist for steel tool company. Salary $4500.00. Cleveland location preferred. Address 4-10.

METALLURGIST—Eight years experience in research, metallography, heat treatment, complaint and service work; High speed, tool steel and cast cutter work. Address 3-30

CHEMIST OR HEAT TREATER—Technical graduate. Experience in chemical and physical testing, heat treating of steels, platinum metals and rare earths. Best of references. Reasonable salary. Address 12-10.

POSITIONS OPEN.

WANTED—Young college graduate with one or two years practical experience in physical metallurgy to carry out physical tests and microexamination work in government bureau. Entrance salary $1800 per annum. Position offers excellent opportunity to become familiar with certain phases of physical metallurgy of great practical value. Address 4-32.

COMMERCIAL HEAT TREATING PLANT—A young man not afraid of work who is willing to give his best efforts so that he can advance in confidence of the employer and ultimately attain a position of responsibility. Experience desirable, but not necessary. Plant located in Cleveland. Address 4-50

ADVERTISING SOLICITOR—A well known publication desires an experienced steel salesman to solicit specialized advertising. Salary and commission. Headquarters will be in New York, but unlimited as to territory. Experienced in soliciting advertising not necessary. Address 4-60.

STEEL SALESMAN—To cover Northern Ohio. Must have had selling experience and thoroughly familiar with high speed and carbon tool steels. An excellent opening for someone who can produce results. Address 3-10.

A well known steel firm desires tool steel salesman to work out of Cleveland office. Would consider only a thoroughly experienced man. Address 4-44.

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the Electric Alloy Steel Co., Youngstown, O. Mr. Davis will occupy temporary offices in room 1716 Ford building, Detroit. This company is installing a complete warehouse stock in Detroit, and the district offices will be moved to the new warehouse as soon as arrangements are completed.

Standardization work in Japan recently was given a great impetus by the organization of the Japanese Engineering Standards Committee. The main function of this committee is to serve as a bureau for solving and initiating problems involving engineering standardization. The committee consists of 70 members presided over by the minister of the department of agriculture and commerce acting as president, and a vice president, who is elected or appointed. The details of the work are handled by seven secretaries who are engineers of the government departments of agriculture and commerce, communications, railways, military engineers and naval engineers. The work is being pushed with vigor, investigations already being under way on metals, woods, bricks, screws, electric wires and electric motors. In Norway a national standardization committee has been organized by the Federation of Norwegian Industries. There are now national standardizing bodies in the following fourteen countries: Austria, Belgium, Canada, Czechoslovakia, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Sweden, Switzerland and the United States.

At the adjourned annual meeting of the American Engineering Standards Committee held in New York recently Albert W. Whitney, a repre-

sentative of the National Safety Council was elected chairman, and George C. Stone, a representative of the American Institute of Mining and Metallurgical Engineers, was re-elected vice-chairman. Mr. Whitney is associate general manager of the National Bureau of Casualty and Surety Underwriters.

L. S. Cope, formerly metallurgical engineer for the Hoover Steel Ball Co., Ann Arbor, Mich., has taken charge of the metallurgical work of the National Screw & Tack Co., and the Cleveland Motorcycle Mfg. Co., both of which are located in Cleveland.

Samuel R. Robinson has resigned as foundry superintendent of the Sandusky Foundry & Machine Co., Sandusky, O., to accept a position as metallurgist of the Lorain Foundry Co., Lorain, O. From 1918 to 1921 Mr. Robinson was metallurgist for the Philadelphia Roll & Machine Co., Philadelphia, and prior to that he was for 11 years metallurgist for the Duquesne Steel Foundry Co., Coraopolis, Pa.

The Society of Automotive Engineers has just issued the announcement that its 1922 summer meeting will be held at White Sulphur Springs, W. Va. The date selected is June 20-24. Plans are being made for the customary sports, entertainment and technical programs.

The address of the St. Louis office of the Chicago Flexible Shaft Co., Chicago, has been changed from the Railway Exchange building to 420 Wainwright building.

Keith Reeves Rodney, formerly metallurgist of the Bullard Machine Tool Co., Bridgeport, Conn. and first chairman of the Bridgeport Chapter of the American Society for Steel Treating, is with the process and development department of the American Chain Co. and is at the present time doing some important work at the plant of the Highland Iron & Steel Co., Terre Haute, Ind.

Boston offices at 79 Milk street, have been opened by the Celite Products Co.

The Gas Combustion Co., Pittsburgh, will remove its offices from the Union Arcade building, on or about April 1.

A number of changes have been made recently in the sales organization of the Celite Products Co., several new offices being opened. Branch offices have been established in Boston, Buffalo, Cincinnati and Minneapolis. F. W. Emerson has been placed in charge of the Boston office, W. D. Van Arnam is district manager of the Buffalo territory, L. M. Lindsey is in charge of the Cincinnati office and E. R. LaBelle is at Minneapolis. A

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SIMONDS
STEEL
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High Speed Steel
Magnet Steels
Chrome Ball and Bearing Steels
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Special Steels

TO know that the steel ordered today will duplicate in every respect that which gave unusual efficiency six months ago, is a satisfaction to the consumer made possible only by years of experience in making QUALITY Steels UNIFORM at all times.

SIMONDS STEEL in your hardening room allows you fixed temperatures in heat treating and eliminates those costly "trouble days".

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For Particular Hard Usage

Bars Sheets Billets

SIMONDS MANUFACTURING CO.
STEEL MILLS
LOCKPORT, N. Y.

Edgar T. Ward Sons Co., Distributors

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change has also been made in the New Orleans office, J. C. Etheredge now being the district manager for that territory.

W. E. Peterson, metallurgical engineer for the Atlas Crucible Steel Co., has resigned effective April 1, to accept the position of manager of alloy steel division with the Electric Alloy Steel Co., Youngstown, O. Prior to the position which Mr. Peterson held with the Atlas Crucible Steel Co., he spent 12 years with the Packard Motor Car Co. as supervisor of materials in charge of metallurgical laboratories, heat treating departments, etc.

To meet a growing need for specialists in metallographic analyses the college of engineering of the University of Wisconsin, Madison, Wis., has established a course in metallography in the department of mechanical engineering, with an enrollment of 60 students. The work is in charge of Prof. Louis Probst of the department of engineering, and covers an intensive study of alloys and alloy steels to train engineers to take places as consulting experts for manufacturing plants manufacturing high grade machinery and mechanical devices which maintain their own departments of analysis or inspection.

High temperature cements and granular refractories are to be manufactured by the Keystone Refractories Co. which has been organized by F. W. Reisman and D. E. Turk with offices at 120-122 Liberty street, New York and plant in Jersey City, N. J. Mr. Reisman, who is president of the new company, formerly was traveling sales manager of the Quigley Specialties Co., New York. Mr. Turk, who was treasurer of the Quigley company, is secretary and treasurer of the Keystone organization.

John McConnell has again become affiliated with the United Alloy Steel Corp., Canton, O., as vice president in charge of operations. He gained distinction in the early days of the United Steel Co., later merged in the United Alloy Steel Corp., in producing the first vanadium steel in commercial quantities. His experience comprises 10 years with the Carnegie Steel Co., three years with the Bethlehem Steel Co., 11 years with the United Steel Co., where he was general superintendent, one year with the Central Steel Co., as consulting metallurgist, and three years as vice president in charge of alloy steel production with the Interstate Iron & Steel Co., Chicago.

The Engineering and Mining Journal, New York, has acquired *The Mining and Scientific Press*, San Francisco. The two papers will be merged and with the issue of April 1 the joint title will be the *Engineering and Mining Journal-Press*. J. E. Spurr will be editor and T. A. Rickard will be contributing editor.